CITY OF BALTIMORE

Sheila Dixon
Mayor

DEPARTMENT OF PUBLIC WORKS

David E. Scott
Director

BUREAU OF WATER AND WASTEWATER

WATER & WASTEWATER ENGINEERING DIVISION

Jones Falls Sewershed Evaluation Study Plan
Project 994

Baseline Analysis and Capacity Assessment

Sanitary Sewer Overflow Consent Decree
Civil Action No. JFM-02-1524

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Kishia L. Powell, Head
Bureau of Water & Wastewater

Jaswant Dhupar, Chief
Water & Wastewater Engineering

in association with

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EXECUTIVE SUMMARY

As part of Baltimore City Project No. 994, Rummel, Klepper and Kahl, LLP and KCI Technologies, Inc. have developed a calibrated hydraulic model of the Jones Falls sewershed within the City of Baltimore. This report outlines the analysis of the collection system under baseline and future conditions. This report identifies areas that experience surcharged or overflows under seven different design storms.

The modeling software selected for the City of Baltimore Collection System Evaluation and Sewershed Plan is InfoWorks CS, by Wallingford Software, Ltd. The model includes all manholes, junctions, and structures along model sewer lines and all control structures (e.g. weirs and pumping stations) existing in the system as required to accurately portray the collection system. The model for the Jones Falls Sewershed includes over 403,000 linear feet of pipe, 2,551 manholes, two pumping stations, 11 weirs, 32 sluice gates, and two flumes. There are also six sources of inflow from Baltimore County and two outfall level condition that are included in the model.

A number of engineered sanitary sewer overflow manholes (SSOs) have been eliminated in the Jones Falls Sewershed over the past several years. There are four known engineered SSOs that remain that have yet to be eliminated.

Baseline conditions are defined by the City to be the conditions in effect after the completion of Paragraph 8 projects in the sewershed. These projects, either completed or under construction, are included as part of the baseline model.

The Consent Decree states that future conditions shall be based on projections for populations and sewer condition deterioration. The City has decided that the future projections will be based on Year 2025 to provide consistency with the Consent Decree for Baltimore County. Future population estimates are based on projections determined by the Baltimore Metropolitan Council. The hydraulic impact of pipe deterioration has been represented by increasing groundwater infiltration by 10 percent over the planning period.

The calibrated hydraulic model has been run for both dry weather flow and wet weather flows to identify areas of the Jones Falls collection system which lack adequate capacity to pass the projected flows for the various storm events. The wet weather storm events have been modeled using the seven design storm events; the 3 month storm with a duration equal to the time of concentration for the sewershed (5 hours), and the 1, 2, 5, 10, 15, and 20 year, 24 hour duration storms.

The Jones Falls sewershed discharges into the High Level Interceptor, which is part of the High Level Sewershed (HL). At the time of this report, the HL does not have a calibrated model. Therefore the downstream levels for the three discharge points (Lower Jones Falls Interceptor, Greenmount Interceptor, and the Jones Falls Pressure Sewer) are estimated from currently available information. It is recommended that once the HL has a fully calibrated model, the downstream level conditions be refined for the Jones Falls. Once this is done, the Jones Falls model should be rerun to verify the results.

An assessment of the baseline conditions for dry weather capacity was completed. The level of sewage in each pipe has been determined and is depicted on mapping included with this report. There are no overflows in the system during dry weather. However, there are several pipe segments that surcharge during peak dry weather flows. The most critical location is the main interceptor in the Lower Jones Falls. According to field investigations along the Lower Jones Falls, the 50-inch to 75-inch diameter pipe is over half full of sediment in some locations. Along with reported sediment issues in the High Level Interceptor, the elevated sediment levels decreases the hydraulic capacity of the Lower Jones Falls Interceptor.

One of the requirements of the CD is to run a Return Period Analysis (RPA) for the seven design storms. The results of the baseline and future flooding RPA are depicted on maps included with this report.

In late 2007, upgrades to the Jones Fall Pumping Station were completed to increase the capacity of the station from 36 MGD to 55 MGD. While there are four pumps at the station, only three can run at one time. The backup pump is truly that, a back-up pump which can only come online if another pump is out of service. Based on this fact, the model was not run with all four pumps, only with three operating and the fourth off-line. The Stony Run Pumping Station, currently under construction, is a wet weather pumping station (SC 847) that will activate during elevated flow conditions. During normal dry weather conditions the station is not in use and the flow bypasses the station. Expected to be completed in early 2009, the station consists of four variable speed pumps. As with the Jones Falls Pumping Station, the fourth pump is a back-up pump and can not be activated while the other three pumps are online. Therefore, the station was only modeled with the three active pumps, with the backup offline. The station is designed so that once the station is activated, 9 MGD bypasses the station and the rest is pumped to the Jones Falls Pressure Sewer.

One of the requirements of the Consent Decree is to identify and map all components of the wastewater collection system that restrict flow of wastewater through the collection system that cause or contribute, or are likely to cause or contribute, to overflows from the collection system. The results of this analysis for both baseline and future conditions are depicted on maps included with this report.

Under dry weather flows there are no overflows in the Jones Falls. However, beginning at the 3-month storm event, for both baseline and future conditions, sanitary sewer overflows (SSOs) begin to occur. Estimates of the total SSO volumes and the locations of each SSO for each design storm are provided.

1.0 PROJECT DESCRIPTION

1.1 Project Location

The Jones Falls Sewershed encompasses approximately 16.5 square miles within the City of Baltimore, as depicted on Figure 1.1. Sewage from Baltimore County flows into the City's Jones Falls sewershed at six locations. The sewershed population within the City is approximately 144,000 and is highly developed. The study area includes the Jones Falls Sewershed and consists of approximately 1,611,000 linear feet (LF) of gravity sewer ranging from 8- to 100-inches in diameter; approximately 8,260 manholes and structures; 37,000 LF of force main, pressure sewer and siphons; and two sewage pumping stations.

The Jones Falls sewershed encompasses a section of the city in the north central portion of the City, as depicted on Figure 1.1. The boundaries are roughly York Road to the east, Park Heights Avenue on the west, and the City-County line on the north and Preston Street on the south.

1.2 Sub-Sewersheds

The Jones Falls Sewershed consists of a total of nine sub-sewersheds. These are listed in Table 1.2 below:

TABLE 1.2 SUB-SEWERSHEDS WITHIN THE JONES FALLS SEWERSHED	
Upper Jones Falls	Barclay Street
Lower Jones Falls	Greenmount Avenue
Western Run	Bolton Hill
Stony Run	Maryland Avenue
Hampton Avenue	

The boundaries for each of the sub-sewersheds are depicted on Figure 1.1.

1.3 Consent Decree Requirements

A Consent Decree (CD) was agreed upon between the City of Baltimore, the United States Environmental Protection Agency and the Maryland Department of the Environment in September, 2002. As stipulated on page 32 of the CD, the hydraulic model must be capable of determining:

1. The flow capacity of each of the pumping stations in the collection system;
2. The flow capacity of each pumping station with its back-up pump out-of-service;
3. Peak flows for each pumping station during storm events of a magnitude of up to 20 years;
4. Likelihood and location of overflows(s) within a service area under high flow conditions, including pumping station service areas where the pumping station's

back-up pump is out-of-service, and considering available wet well capacity, off-line storage capacity, and normal in-line storage capacity.

In Paragraph 9.C of the CD, it states that it will be necessary to determine the range of storm events for which the collection system in its existing condition can convey peak flows without the occurrence of sanitary sewer overflows. As part of the analyses, all modeled components of the collection system that cause or contribute to flow restrictions or that have the potential to cause or contribute to overflows are identified.

1.4 Guidelines and Requirements

As specified in by Consent Decree and City of Baltimore, after the hydraulic model has been calibrated and approved by the Technical Program Manager, it shall be used to analyze the collection system under baseline and future conditions for seven design storms. These design storms include: the three-month storm having a duration equal to the time of concentration for the sewershed (5 hours); the 20-year 24-hour duration storm; and the 1-, 2-, 5-, 10-, and 15-year, 24 hour storms.

Baseline conditions have been defined as after the Paragraph 8 projects have all been completed. Future conditions have been selected to be the conditions for Year 2025. The hydraulic impact of pipe deterioration will be accounted for by increasing the groundwater infiltration by 10 percent over the planning period. Future conditions also account for projections of population and employment changes. Additionally, any proposed improvements in addition to the Paragraph 8 projects but scheduled to be completed before Year 2025 are to be included in the future conditions model. However, there are no planned activities within the Jones Falls as of this time.

The requirements stipulated in the Consent Decree and by the City of Baltimore for the pumping station analyses include:

1. Determine the current dry weather flows (minimum and average) and peak wet weather flow for the selected design storms contributing to each pumping station;
2. Project the future dry weather flows (minimum and average) and peak wet weather flow for the selected design storms contributing to each pumping station;
3. Evaluate the hydraulic capacity of all force mains and pumping stations to convey current and future dry and wet-weather flows;
4. Evaluate the capacity of all major pumping station components to handle current dry and future dry and wet weather flows including: stand-by power generator; wet-well size; pumps; motors; electrical gear (starters, VFDs, etc.); flow metering;
5. Peak flows for each pumping station during the selected design storms
6. Likelihood and location of overflows within a service area under high flow conditions, including pumping station service areas where the pumping station's back-up pump is out-of-service, and considering wet well capacity, off-line storage capacity, and normal in-line storage capacity.

2.0 HYDRAULIC MODEL

2.1 Hydraulic Model Network

2.1.1 General Description

As stated in the Consent Decree, the modeled network shall include all force mains, major gravity lines, and pumping stations and their respective related appurtenances. Major gravity lines are defined in the Consent Decree as:

- all gravity lines ten inches in diameter or larger;
- all eight-inch lines that convey or are necessary to accurately represent flow attributable to a service area in each of the Collection System's sewershed service areas;
- all gravity lines that convey wastewater from one pumping station service area to another pumping station service area; and
- all gravity lines that have caused or contributed, or that the City knows are likely to cause or contribute, to capacity-related overflows (utilizing the Water In Cellar (WIC) database).

The modeling software selected for the City of Baltimore Collection System Evaluation and Sewershed Plan is InfoWorks CS, by Wallingford Software, Ltd. An evaluation team for the City selected this modeling software among others available as the best suited for the City of Baltimore system. As of the date of this report, the most recent version is InfoWorks CS 9.02.

The horizontal datum used for the hydraulic modeling is the Maryland State Plane Coordinate System (NAD83). The vertical datum used is NAVD88.

The model includes all manholes, junctions, and structures along model sewer lines and all control structures (e.g. weirs and pumping stations) existing in the system as required to accurately portray the collection system.

The City's wastewater geodatabase was used as the primary source of information for creating and populating the pipes and nodes network of the InfoWorks hydraulic model. RK&K utilized the manhole inspection and CCTV information from project field survey efforts, along with City engineering documents from the AIRS archive, to make numerous editing changes and enhancements to the City's wastewater GIS. A more detailed description of the development of the hydraulic model is contained in the May 2008 *Final Model Development and Calibration Report*.

The model for the Jones Falls Sewershed includes over 403,000 linear feet of pipe, 2,551 manholes, two pumping stations, 10 weirs, 36 sluice gates, and two flumes. There are also six sources of inflow from Baltimore County and two outfall level conditions that are included in the model.

2.1.2 Paragraph 8 Projects

A series of construction projects, referred to as Paragraph 8 projects, have been completed or are under construction within the Jones Falls sewershed. The purpose of these projects is to reduce the frequency and volumes of sanitary sewer overflows. A listing of the Paragraph 8 projects are presented in Table 2.1.2, all of which have been represented in the model as required.

TABLE 2.1.2
PARAGRAPH 8 PROJECTS IN THE JONES FALLS SEWERSHED

Sanitary Contract No.	Sub-Sewershed	Description	Actual or Projected Completion Date	SSOs Eliminated
SC760	Western Run	Install 880 feet of 30" parallel relief sewer	September 2004	21, 22, 23, 24, and 29
SC789	Western Run	Install 9400' of 21" to 24" parallel relief sewer, also rehabilitate 3300' of ex. 18" sewer	November 2003	21, 22, 23, 24, and 29
SC772	Upper Jones Falls	Rehabilitate 1800' ex. 42"-48" sewer & 6570' of 48-60" sewer; Replace 1900' of 48" sewer & 1550' of 60" sewer	April 2006	33 and 34
SC824	Upper Jones Falls	Replace 7,080' of 48" sewer	December 2006	33 and 34
SC779	Lower Jones Falls	Replace 1600' of force main/pressure sewer in Broadway from Oliver to East Chase Street connecting to High Level sewer	June 2004	5
SC805	Lower Jones Falls	Improvements to gate valves, blow-off valves and air release valves for existing force main/pressure sewer	January 2005	5
SC800	Lower Jones Falls	Upgrade ex force main to handle increased flows from the rehabilitated Jones Fall PS as well as additional flows from the Stony Run pumping station.	November 2007	5
SC822	Lower Jones Falls	Upgrade existing pumping station to handle at least 50 mgd	November 2007	5
SC876	Western Run	Assess hydraulics and design improvements to areas adjacent to overflows	June 2004	20, 31, 32, and 36

TABLE 2.1.2
PARAGRAPH 8 PROJECTS IN THE JONES FALLS SEWERSHED

Sanitary Contract No.	Sub-Sewershed	Description	Actual or Projected Completion Date	SSOs Eliminated
SC773R	Lower Jones Falls	Rehabilitate 16,500' of ex sewer from 12" to 50", also rehabilitate inverted siphon in Falls Rd	February 2005	67
SC818	Lower Jones Falls	Install 7,900' of 18" to 24" parallel relief sewer	June 2006	67
SC819R	Stony Run	Upper portion of Stony Run interceptor north of Cold Spring Lane	October 2006	72 and 129
SC838	Stony Run	Middle portion of Stony Run interceptor between north of Cold Spring Lane and West Northern Parkway.	March 2007	72 and 129
SC839	Stony Run	Lower Stony Run Interceptor	February 2009	72 and 129
SC847	Stony Run	20 mgd Stony Run PS and force main	November 2008	72 and 129
SC799	Maryland Avenue	Replace 4,400' of ex. 12" to 24" sewer with new 21" to 36" sewer along branch interceptor	July 2005	69 and 125
SC820	Greenmount Avenue	Install approximately 7,325 linear feet of 36 to 42-inch parallel relief sewer from Bonaparte Ave. to the High Level interceptor on Eager Street.	May 2007	72
SC833	Greenmount Avenue	Line approximately 6,000 linear feet of 15- to 33-inch existing sewer	January 2008	72
SC830		Cleaning and inspection of siphon with repairs as necessary.	June 2004	68

2.1.3 Engineered SSO Locations

A number of engineered sanitary sewer overflow manholes (SSOs) have been eliminated in the Jones Falls Sewershed over the past several years. There are four known engineered SSOs that remain and have yet to be eliminated. These SSOs are listed in Table 2.1.3 below:

TABLE 2.1.3 SANITARY SEWER OVERFLOWS REMAINING IN THE JONES FALLS SEWERSHED				
SSO Number	Location	Sub-Basin	Receiving Waters	Manhole Number
33	Opposite of 5730 Cotton worth Avenue, In Front Of Post Office	Upper JF	Jones Falls	S19EE2_056MH
34	600 Feet South of Post Office	Upper JF	Jones Falls	S19CC2_037MH
67	200 Feet South of Falls Road	Lower JF	Jones Falls	S31MM_013MH
72	Rear of 428 E. Preston Street in RR Yard	Lower JF	Jones Falls	S37GG_007MH

Figure 1.1 depicts the locations of the remaining active SSOs in the Jones Falls Sewershed.

2.2 Hydraulic Model Calibration

2.2.1 General

The hydraulic model of the Jones Falls Sewershed has been calibrated for both dry weather and wet weather flows. A detailed description of the model calibration is contained in the May 2008 *Final Model Development and Calibration Report*.

2.2.2 Summary of Dry Weather Calibration

Sources of data used in determining the dry-weather flows included: rainfall/flow monitoring data; the City's database of water consumption records; population estimates; estimates of tributary collection system to each flow monitors; and estimates of the tributary sewershed area to each flow monitor. The flow analyses obtained using the Sliicer.com software provides estimates of the components of the dry-weather flow; the average base sanitary flow (BSF) and the groundwater infiltration (GWI) rate at each flow monitoring site. The BSF is estimated as the dry weather flow rate less the GWI estimate. In cases where net negative GWI was a problem, the GWI has been estimated as a percentage of the BSF based on gross measurements. These values were validated prior to input to the InfoWorks model.

The Sliicer.com analyses yields average daily dry weather flow hydrographs for each monitoring basin for both weekdays and weekends. This data was then used to develop hourly diurnal peaking factors for weekdays and weekends. This was done by first subtracting the GWI from the hourly values of the dry weather flow hydrographs and then dividing by the average BSF.

The dry weather calibration began with incorporating significant defects identified during the CCTV inspection. Sediment depths, blockages, and other flow restrictions were identified and then incorporated into the model. Based on the type of defect identified, Manning's "n" values were changed to reflect increased roughness. "Observed vs. Predicted" plots were generated at each flow monitoring sites to see how the model behaves compared to the flow meter data. Any sites that require modification to meet flow depth, volume of flow, and velocity were adjusted to match the flow meter.

The hydraulic model at the meter locations in the Jones Falls meets the established requirements of the City of Baltimore and the Consent Decree for dry weather calibration. The shape and timing of the hydrographs were compared to the observed and any major discrepancies were corrected. Depths and velocities were compared and the roughness factors and sediment depths (corresponding to field work investigations) were adjusted to match the observed. The model simulations time period for the dry weather calibration was run for one week and the volumes of the predicted vs. observed are totaled by InfoWorks for the time period. The curves were visually inspected to ensure all peak flow rates generally matched.

2.2.3 Summary of Wet Weather Calibration

The approach to simulate wet weather flow uses the SWMM RUNOFF routines in InfoWorks CS as a synthetic storm hydrograph generator. Simulating rainfall-dependent infiltration and inflow (RDII) using SWMM RUNOFF within InfoWorks requires the specification of catchment characteristics that result in correct RDII. The parameters specified are: area; R-value; depression storage; width; slope; and overland flow routing coefficient.

The RDII volume versus rainfall depth plot for each monitoring site was developed using the Sliicer.com software. After reviewing the results and looking at all of the storm events, the parameters as mentioned above were adjusted to more accurately predict the flow meter responses.

To assess the validity of the model, a series of graphs (statistical comparison plots) were produced as outlined by the City of Baltimore. Ideally a regression line with an R^2-value close to 1.00 indicates the goodness-of-fit between the modeled and observed peak flows and volumes, and an intercept of the regression line close to zero indicates that the modeled event volumes and peak flow rates are not biased (i.e., consistently over-predicting or under-predicting) with respect to the monitored volumes and peak flow rates. However, when using the median "R" value as discussed above, regression lines tend to vary from those parameters. The summer type storms have less I/I per rain depth than the winter storms. This skews the graph away from the ideal situation. The design storms to be used in the capacity analysis are more typical of the summer type storms rather than the winter type storms. With the Jones Falls model calibrated to a middle range, this provides a conservative capacity estimate, while not over-designing alternatives. In addition, the observed vs. predicted graphs generated by InfoWorks were reviewed to assess the shape and timing of the hydrographs.

The hydraulic model of the Jones Falls Sewershed has been built in accordance with the Consent Decree and as outlined by the City of Baltimore. The wet weather calibration uses a median "R" value to capture the differences between winter and summer storm events. However, when looking at all of the modeled storm events as a whole and balancing the differences, the model behaves in a realistic fashion.

Field work is ongoing in the Jones Falls basin to assist in identifying sources of high infiltration and inflow. As information becomes available, it will be utilized in the development of recommendations for the Jones Falls Sewershed. See Figure 2.2.3A for a map depicting the "R" values for each flow meter basin and Figure 2.2.3B for a map depicting average daily infiltration normalized to gallons per inch-diameter-mile per flow meter basin.

3.0 BASELINE ANALYSIS AND CAPACITY ASSESSMENT

3.1 General

Baseline conditions are defined by the City to be the conditions in effect after the completion of Paragraph 8 projects in the sewershed. The calibrated hydraulic model was updated with either as-built drawings or as-bid drawings, depending on the status of the Paragraph 8 projects. The calibrated hydraulic model has been run for both dry weather flow and wet weather flows to identify areas of the Jones Falls collection system which lack adequate capacity to pass the projected flows for the various storm events. The wet weather storm events that have been modeled include the three-month storm having a duration equal to the time of concentration for the sewershed (5 hours); the 20-year 24-hour duration storm; and the 1-, 2-, 5-, 10-, and 15-year, 24 hour storms. Maps have been created showing the results of the return period analysis and hydraulic flow restrictions.

The Jones Falls sewershed discharges into the High Level Interceptor, which is part of the High Level Sewershed (HL). At the time of this report, the HL does not have a calibrated model. Therefore the downstream levels for the three discharge points (Lower Jones Falls Interceptor, Greenmount Interceptor, and the Jones Falls Pressure Sewer) are estimated from currently available information. It is recommended that once the HL has a fully calibrated model, the downstream level conditions be refined for the Jones Falls. Once this is done, the Jones Falls model should be rerun to verify the results.

3.2 Dry Weather Capacity Assessment

An assessment of the baseline conditions for dry weather capacity was completed. There are no overflows in the system during dry weather. However, there are several pipe segments that surcharge during peak dry weather flows. The locations are highlighted in red as shown on Figure 3.2. Figure 3.2 displays the peak percent full each pipe is during dry weather flow. The most critical location is the main interceptor in the Lower Jones Falls. According to field investigations along the Lower Jones Falls, the 50-inch to 75-inch diameter pipe is over half full of sediment in some locations. Along with reported sediment issues in the High Level Interceptor, the elevated sediment levels decreases the hydraulic capacity of the Lower Jones Falls Interceptor. With 36 inches of sediment in the Lower Jones Falls, the capacity is about 25 MGD just before the outfall to the High

Level Interceptor. However for the same pipe with no sediment, the capacity increases to 78 MGD (not counting back water influences from the High Level Interceptor). The other pipes that are surcharged are at locations were a smaller diameter side branch enters a larger diameter interceptor at the invert rather than matching crowns and were there are depressions in the sewer reach.

The pipes that are 75 percent full or greater during dry weather flows are highlighted in purple on Figure 3.2. A pipe that is ¾ full during dry weather does not provide adequate capacity for future growth or wet weather flows. The pipe segments that are 75 percent full during dry weather are highlighted in orange on Figure 3.2. The main causes of the elevated water levels are generally the same as discussed in previous section. An exception is located just upstream of the Jones Fall Pump Station. This reach of sewer reaches the 75 percent full mark just before a second pump turns on at the pump station and is therefore not an area of significant concern for the dry weather capacity assessment.

3.3 Wet Weather Capacity Assessment

3.3.1 Storm Events

As stated earlier, there are seven design storms that are to be analyzed. These design storms include a three-month storm having a duration equal to the time of concentration for the sewershed (5 hours) and the 1, 2, 5, 10, 15, and 20-year, 24 hour duration storms. The storm distribution chosen for analysis is the NOAA Atlas 14/NRCS distribution. The storm depths for the seven design storms are as follows:

- 3 Month – 1.11 inches
- 1 Year – 2.67 inches
- 2 Year – 3.23 inches
- 5 Year – 4.15 inches
- 10 Year – 4.97 inches
- 15 Year – 5.41 inches
- 20 Year – 5.82 inches

3.3.2 Return Period Analysis

One of the requirements of the CD is to run a Return Period Analysis (RPA) on the seven design storms. InfoWorks compares the surcharge state and any flooding based on each design storm and presents the minimum size storm required to surcharge and flood (cause an overflow) a pipe segment, along with the estimated flood volume. This is accomplished by selecting all of the simulations based on the design storms and loading them into the Grid Report results menu and selecting the RPA option in InfoWorks CS. The results of the baseline flooding RPA are presented in Figure 3.3.2A, 3.3.2B, and 3.3.2C

3.3.3 Jones Falls Pumping Station Analysis

In late 2007, upgrades to the Jones Fall Pumping Station were completed to increase the capacity of the station from 36 MGD to 55 MGD as part of a Consent Decree mandated Paragraph 8 project. The upgrades included replacement of all parts of the pump station from downstream of the screens to the discharge of the station. Since the pumping station was upgraded per Paragraph 8 of the Consent Decree, a full detailed inspection of all system components under this project was not required. The station currently has four variable speed pumps with a maximum capacity of 18 MGD each. While there are four pumps at the station, only three can run at one time. The backup pump is truly that, a back-up pump which can only come online if another pump is out of service. Based on this fact, the model was not run with all four pumps, only with three operating and the fourth off line.

The minimum dry weather flow to the pump station is 9.2 MGD and the average daily dry weather flow is 14.3 MGD. The peak flow rates for the pump station are presented below in Table 3.3.3.

TABLE 3.3.3
JONES FALLS PUMPING STATION BASELINE CAPACITY ANALYSIS**

Event	Peak Incoming Flow Rate (MGD)	Peak Discharge Flow Rate (MGD)	Peak Bypassed Flow* Rate (MGD)	Peak Velocity (fps) in 48" FM	Peak Velocity (fps) in 54" FM++
DWF	17.53	17.63	0.00	3.10	2.30
3 Month	30.41	30.52	0.00	3.76	2.98
1 Year	48.89	48.74	0.00	6.00	5.62
2 Year	55.80	51.90	4.00	6.40	6.20
5 Year	60.85	52.87	8.07	6.51	6.37
10 Year	63.68	52.87	10.89	6.51	6.47
15 Year	64.83	52.90	12.96	6.52	6.62
20 Year	65.99	52.92	13.17	6.52	6.82

* For flow above the capacity of the station, the flow bypasses to the Lower Jones Falls Interceptor.
**The flow rates are peak instantaneous flow rates at three different locations which could occur at different times.
++Includes flow from the Stony Run Pumping Station

The Jones Falls Pumping Station discharges into a recently constructed 48-inch force main constructed under SC 800. The force main transitions to a 54-inch diameter line following the confluence of the 30-inch force main from the Stony Run Pumping Station. The force main then reduces down to a 42-inch diameter pressure sewer (SC 779) outside of the Jones Falls sewershed and discharges into the High Level Interceptor. It is important that the velocities within the force main do not become too elevated to prevent excessive head on the pumps and protect the system from scour effects. For capacity analysis of force mains in the Jones Falls sewershed, velocities of greater then 7 feet per second are considered excessive and is the maximum velocity to be allowed. As shown in Table 3.3.3, the velocities remain below 7 feet per second; however there is no room to increase the pump station capacities without further upgrades to the force main or system modifications.

3.3.4 Stony Run Pumping Station Analysis

The Stony Run Pumping Station is a wet weather pumping station (SC 847) that only activates during elevated flow conditions. During normal dry weather conditions the station is not in use and the flow bypasses the station. Expected to be completed in early 2009, the station consists of four variable speed pumps with a maximum capacity of 8.5 MGD each. As with the Jones Falls Pump Station, the fourth pump is a back up pump and can not be activated while the other three pumps are online. Therefore, the station was only modeled with the three active pumps, with the backup offline. The station is designed so that once the station is activated, approximately 9 MGD bypasses the station and the remaining flow is pumped to the Jones Falls Pressure Sewer.

Since the Stony Run Pumping Station is only a wet weather pumping station, it does not have a minimum and average daily flow. The peak flow rates for the pump station for the various design storms are presented in Table 3.3.4.

TABLE 3.3.4
STONY RUN PUMPING STATION BASELINE CAPACITY ANALYSIS**

Event	Peak Flow Incoming Flow Rate (MGD)	Peak Discharge Flow Rate (MGD)	Peak Bypassed Flow Rate (MGD)	Peak Velocity (fps) in 30" FM
DWF	4.20	0.00	4.20	0.00
3 Month	7.72	0.00	7.72	0.00
1 Year	13.42	10.77	9.14	3.40
2 Year	15.98	11.63	9.39	3.67
5 Year	19.59	12.62	9.46	3.98
10 Year	23.17	13.75	9.56	4.34
15 Year	24.91	16.10	9.61	5.07
20 Year	26.00	17.21	9.61	5.43

**The flow rates are peak instantaneous flow rates at three different locations which could occur at different times.

The Stony Run Pumping Station will discharge into a 30-inch diameter force main being constructed under SC 847. The force main then discharges into the Jones Falls 54-inch diameter force main. The maximum allowed velocities within the force main, just like the Jones Falls Pumping Station's force main is 7 feet per second. As shown in Table 3.3.4, the Stony Run Pump Station's force main is in compliance with the velocity threshold and even has additional capacity available. However, this force main discharges into the Jones Falls 54-inch diameter force main, which is near capacity.

3.3.5 Predicted SSO Overflows

Under dry weather flows there are no overflows in the Jones Falls. However, beginning at the 3 month storm event, sanitary sewer overflows (SSOs) begin to occur. The overflows begin in the Lower Jones Fall Interceptor, as shown in Figures 3.3.2A, 3.3.2B, and 3.3.2C. The figures depict the smallest storm event to first begin overflowing a manhole. This section of the collection system is highly dependant on the hydraulics of the High Level Interceptor. As discussed in Section 3.1, the level condition for the HL was estimated with available information; however, the Jones Falls model should be rerun following coordination with the HL model to verify all results. A summary of the SSO volumes for each of the engineered overflows and all manholes, based on the storm return period are shown in Table 3.3.6A. Table 3.3.6B shows each manhole ID and SSO volume for each corresponding storm.

TABLE 3.3.5A
BASELINE SSO VOLUMES

Event	All Manholes (MG)	SSO 33 (MG)	SSO 34 (MG)	SSO 67 (MG)	SSO 72 (MG)	Total (MG)
3 Month	0.165	0.000	0.000	0.592	0.000	0.757
1 Year	4.802	0.000	0.000	1.143	0.537	6.482
2 Year	6.048	0.370	0.218	1.928	0.626	9.190
5 Year	13.714	1.247	0.718	3.357	3.613	22.650
10 Year	22.813	1.810	1.155	2.196	3.584	31.558
15 Year	27.743	2.058	1.366	2.229	3.631	37.027
20 Year	31.707	2.260	1.528	2.235	3.674	41.403

TABLE 3.3.5B
BASELINE MANHOLE SSO VOLUMES

	Manhole ID	3 month (MG)	1 Year (MG)	2 Year (MG)	5 Year (MG)	10 Year (MG)	15 Year (MG)	20 Year (MG)
1	S31KK_099MH	0.0867	0.9270	1.732	2.951	5.9686	7.1345	7.6159
2	S35GG_086MH	0.0787	3.7183	3.6131	6.3475	6.5962	6.6607	6.7148
3	S31CC_039MH	-	0.0516	0.0728	0.108	0.1364	0.1522	0.1674
4	S31CC_016MH	-	0.0591	0.0929	0.1259	0.1514	0.1652	0.1781
5	S33II1024MH	-	0.0141	0.0353	0.0728	0.1037	0.1200	0.135
6	S33GG_010MH	-	0.0108	0.0440	0.0760	0.1011	0.1143	0.1264
7	S33GG_087MH	-	0.0086	0.0956	0.2498	0.3777	0.4467	0.5100
8	S31GG1008MH	-	0.0074	0.0144	0.0294	0.0427	0.0496	0.0554
9	S31II1003MH	-	0.0037	0.0077	0.0167	0.0256	0.0307	0.0355
10	S31CC_003MH	-	0.0006	0.0361	0.1188	0.1934	0.2343	0.2718
11	S04II2018MH	-	0.0003	0.0263	0.1202	0.2367	0.3081	0.3803
12	S15EE2032MH	-	-	0.1339	0.4058	0.5526	0.6214	0.6806
13	S33GG_002MH	-	-	0.0301	0.1061	0.1762	0.2153	0.2515

TABLE 3.3.5B
BASELINE MANHOLE SSO VOLUMES

	Manhole ID	3 month (MG)	1 Year (MG)	2 Year (MG)	5 Year (MG)	10 Year (MG)	15 Year (MG)	20 Year (MG)
14	S35GG_010MH	-	-	0.0283	0.1139	0.1967	0.2437	0.2882
15	S02AA2008MH	-	-	0.0186	0.0722	0.1111	0.1247	0.1358
16	S33QQ1015MH	-	-	0.0180	0.1294	0.212	0.2616	0.3065
17	S02WW1007MH	-	-	0.0116	0.0983	0.1428	0.1566	0.1671
18	S13EE2013MH	-	-	0.0076	0.0886	0.1305	0.1511	0.1695
19	S35KK1019MH	-	-	0.0071	0.0233	0.0330	0.0378	0.0420
20	S33GG_033MH	-	-	0.0067	0.0119	0.0160	0.0179	0.0191
21	S13EE2026MH	-	-	0.0054	0.1077	0.2395	0.2932	0.3437
22	S11EE2014MH	-	-	0.0044	0.7077	1.2809	1.5296	1.7296
23	S35II1021MH	-	-	0.0029	0.0145	0.0232	0.0268	0.0297
24	S29OO1109MH	-	-	0.0022	0.0455	0.1042	0.1524	0.2081
25	S04AA2005MH	-	-	0.0002	0.1025	0.2391	0.3168	0.3894
26	S33GG_019MH	-	-	0.0002	0.0073	0.0154	0.0201	0.0245
27	S02YY1005MH	-	-	0.0001	0.0113	0.0276	0.0332	0.0374
28	S09CC2101MH	-	-	-	0.3628	0.7355	0.8977	1.0292
29	S19GG2071MH	-	-	-	0.2800	0.7418	0.9707	1.1677
30	S23QQ1006MH	-	-	-	0.1777	0.3742	0.4814	0.5809
31	S07YY1016MH	-	-	-	0.1392	0.2196	0.2512	0.2776
32	S04CC2003MH	-	-	-	0.0471	0.0714	0.0842	0.0963
33	S23EE1021MH	-	-	-	0.0461	0.0755	0.0933	0.1103
34	S23QQ1013MH	-	-	-	0.0419	0.1340	0.1904	0.2453
35	S07YY1001MH	-	-	-	0.0391	0.1658	0.2138	0.2471
36	S33WW_041MH	-	-	-	0.0353	0.1370	0.1955	0.2384
37	S02WW1004MH	-	-	-	0.0304	0.1752	0.2709	0.3645
38	S19EE2014MH	-	-	-	0.0276	0.2696	0.4205	0.5486
39	S17AA2009MH	-	-	-	0.0246	0.0396	0.0459	0.0512
40	S07YY1003MH	-	-	-	0.0187	0.0551	0.0674	0.0769
41	S07AA2026MH	-	-	-	0.0168	0.0451	0.0549	0.0627
42	S17CC2001MH	-	-	-	0.0140	0.0213	0.0244	0.0272
43	S01AA2016MH	-	-	-	0.0133	0.0889	0.1438	0.1980
44	S35KK1001MH	-	-	-	0.0133	0.0379	0.0537	0.0692
45	S07YY1004MH	-	-	-	0.0123	0.0737	0.1002	0.1172
46	S09CC2039MH	-	-	-	0.0110	0.1086	0.1435	0.1715
47	S31OO1005MH	-	-	-	0.0104	0.0203	0.0256	0.0303
48	S17AA2008MH	-	-	-	0.0103	0.0691	0.1068	0.1434
49	S04CC2001MH	-	-	-	0.0090	0.0616	0.0925	0.1213
50	S09AA2002MH	-	-	-	0.0083	0.0437	0.0659	0.0875
51	S23CC1042MH	-	-	-	0.0081	0.0264	0.0372	0.0470
52	S33II1031MH	-	-	-	0.0052	0.0129	0.0170	0.0209
53	S33QQ1005MH	-	-	-	0.0052	0.0125	0.0164	0.0198

TABLE 3.3.5B
BASELINE MANHOLE SSO VOLUMES

	Manhole ID	3 month (MG)	1 Year (MG)	2 Year (MG)	5 Year (MG)	10 Year (MG)	15 Year (MG)	20 Year (MG)
54	S23EE1009MH	-	-	-	0.0049	0.0144	0.0178	0.0211
55	S35QQ1021MH	-	-	-	0.0048	0.0189	0.0271	0.0347
56	S07AA2028MH	-	-	-	0.0046	0.0288	0.0356	0.0408
57	S43UU_020MH	-	-	-	0.0042	0.0089	0.0107	0.0122
58	S33QQ1014MH	-	-	-	0.0041	0.0161	0.0218	0.0263
59	S31EE_015MH	-	-	-	0.0037	0.0270	0.0426	0.0587
60	S11EE2021MH	-	-	-	0.0030	0.0384	0.0632	0.0814
61	S23KK_007MH	-	-	-	0.0029	0.0170	0.0271	0.0373
62	S15UU1001MH	-	-	-	0.0023	0.0567	0.1082	0.1283
63	S17CC2002MH	-	-	-	0.0021	0.0032	0.0037	0.0041
64	S09CC2103MH	-	-	-	0.0018	0.1176	0.2073	0.2933
65	S23EE1010MH	-	-	-	0.0016	0.0033	0.004	0.0044
66	S02YY1011MH	-	-	-	0.0014	0.0237	0.0445	0.0662
67	S31QQ_021MH	-	-	-	0.0011	0.0089	0.0147	0.0205
68	S19AA2060MH	-	-	-	0.0008	0.0079	0.0115	0.0144
69	S05UU1012MH	-	-	-	0.0004	0.0524	0.0922	0.1323
70	S33SS1002MH	-	-	-	0.0002	0.0212	0.0356	0.0497
71	S33SS1005MH	-	-	-	0.0002	0.0091	0.0138	0.0180
72	S31MM_005MH	-	-	-	-	0.3194	0.4728	0.5263
73	S31MM_052MH	-	-	-	-	0.1860	0.2845	0.3311
74	S31MM_054MH	-	-	-	-	0.1596	0.3462	0.4224
75	S13CC2008MH	-	-	-	-	0.0476	0.0695	0.0822
76	S05YY1007MH	-	-	-	-	0.0451	0.1177	0.1921
77	S07YY1013MH	-	-	-	-	0.0327	0.0678	0.0909
78	S33YY1002MH	-	-	-	-	0.0310	0.0659	0.1036
79	S25EE1031MH	-	-	-	-	0.0249	0.0419	0.0579
80	S05II2011MH	-	-	-	-	0.0234	0.0629	0.0878
81	S33KK_010MH	-	-	-	-	0.0229	0.0372	0.0481
82	S17KK1004MH	-	-	-	-	0.0226	0.0311	0.0384
83	S09CC2007MH	-	-	-	-	0.0187	0.0467	0.0682
84	S15MM1003MH	-	-	-	-	0.0180	0.0315	0.0440
85	S13CC2006MH	-	-	-	-	0.0179	0.0208	0.0234
86	S43SS_027MH	-	-	-	-	0.0144	0.0254	0.0326
87	S07AA2022MH	-	-	-	-	0.0142	0.0254	0.0358
88	S02EE2011MH	-	-	-	-	0.0134	0.0309	0.0501
89	S04II2007MH	-	-	-	-	0.0120	0.0296	0.0498
90	S43WW_007MH	-	-	-	-	0.0095	0.0171	0.0249
91	S07YY1018MH	-	-	-	-	0.0093	0.0176	0.0221
92	S19II2024MH	-	-	-	-	0.0084	0.1034	0.2410
93	S09WW1002MH	-	-	-	-	0.0078	0.0195	0.0307

TABLE 3.3.5B BASELINE MANHOLE SSO VOLUMES								
	Manhole ID	3 month (MG)	1 Year (MG)	2 Year (MG)	5 Year (MG)	10 Year (MG)	15 Year (MG)	20 Year (MG)
94	S13AA2012MH	-	-	-	-	0.0057	0.0332	0.0619
95	S15KK1029MH	-	-	-	-	0.0052	0.0070	0.0083
96	S33KK1006MH	-	-	-	-	0.0048	0.0097	0.0148
97	S13OO1017MH	-	-	-	-	0.0039	0.0174	0.0321
98	S35OO_008MH	-	-	-	-	0.0028	0.0162	0.0261
99	S43SS_015MH	-	-	-	-	0.0022	0.0111	0.0224
100	S27II_015MH	-	-	-	-	0.0021	0.0066	0.0113
101	S07YY1008MH	-	-	-	-	0.0012	0.0054	0.0100
102	S05AA2038MH	-	-	-	-	0.0011	0.0078	0.0123
103	S05AA2005MH	-	-	-	-	0.0005	0.0054	0.0086
104	S27AA1035MH	-	-	-	-	0.0003	0.0075	0.0167
105	S33QQ_013MH	-	-	-	-	0.0002	0.0026	0.0045
106	S43SS_033MH	-	-	-	-	0.0001	0.0055	0.0120
107	S15MM1008MH	-	-	-	-	0.0001	0.0017	0.0037
108	S33GG_025MH	-	-	-	-	0.0001	0.0002	0.0001
109	S03WW1010MH	-	-	-	-	-	0.0268	0.0702
110	S17UU1008MH	-	-	-	-	-	0.0265	0.1082
111	S05II2010MH	-	-	-	-	-	0.0159	0.0538
112	S03II2003MH	-	-	-	-	-	0.0129	0.0348
113	S07EE2016MH	-	-	-	-	-	0.0111	0.0399
114	S37YY_007MH	-	-	-	-	-	0.0108	0.0280
115	S11CC2022MH	-	-	-	-	-	0.0099	0.0288
116	S13CC2021MH	-	-	-	-	-	0.0084	0.0211
117	S13UU1015MH	-	-	-	-	-	0.0066	0.0311
118	S13UU1010MH	-	-	-	-	-	0.0063	0.0258
119	S07YY1014MH	-	-	-	-	-	0.0060	0.0169
120	S19CC2048MH	-	-	-	-	-	0.0048	0.0081
121	S21II2012MH	-	-	-	-	-	0.0042	0.0163
122	S21AA2006MH	-	-	-	-	-	0.0034	0.0103
123	S05AA2025MH	-	-	-	-	-	0.0031	0.0135
124	S39AA1011MH	-	-	-	-	-	0.0031	0.0089
125	S35EE1025MH	-	-	-	-	-	0.0030	0.0133
126	S35OO_034MH	-	-	-	-	-	0.0025	0.0106
127	S19GG2020MH	-	-	-	-	-	0.0023	0.0061
128	S11EE2018MH	-	-	-	-	-	0.0018	0.0070
129	S05YY1014MH	-	-	-	-	-	0.0017	0.0179
130	S35MM_004MH	-	-	-	-	-	0.0011	0.0041
131	S45UU_021MH	-	-	-	-	-	0.0009	0.0064
132	S21EE2018MH	-	-	-	-	-	0.0009	0.006
133	S39YY_020MH	-	-	-	-	-	0.0005	0.0029

TABLE 3.3.5B BASELINE MANHOLE SSO VOLUMES								
	Manhole ID	3 month (MG)	1 Year (MG)	2 Year (MG)	5 Year (MG)	10 Year (MG)	15 Year (MG)	20 Year (MG)
134	S33QQ_012MH	-	-	-	-	-	0.0004	0.0019
135	S35YY_009MH	-	-	-	-	-	0.0003	0.0065
136	S23AA1015MH	-	-	-	-	-	0.0003	0.0018
137	S05II2019MH	-	-	-	-	-	0.0002	0.0091
138	S31GG1013MH	-	-	-	-	-	0.0002	0.0009
139	S15KK1013MH	-	-	-	-	-	0.0001	0.0003
140	S06II2006MH	-	-	-	-	-	-	0.0096
141	S08CC2010MH	-	-	-	-	-	-	0.0091
142	S33UU1016MH	-	-	-	-	-	-	0.0079
143	S23YY_060MH	-	-	-	-	-	-	0.0044
144	S03WW1016MH	-	-	-	-	-	-	0.0033
145	S31MM_013MH	-	-	-	-	-	-	0.0016
146	S09UU1001MH	-	-	-	-	-	-	0.0013
147	S08II2005MH	-	-	-	-	-	-	0.0012
148	S35OO_055MH	-	-	-	-	-	-	0.0007
149	S33SS_038MH	-	-	-	-	-	-	0.0006
150	S35YY_036MH	-	-	-	-	-	-	0.0004
151	S13OO1020MH	-	-	-	-	-	-	0.0003
152	S31OO1019MH	-	-	-	-	-	-	0.0003
153	S04CC2008MH	-	-	-	-	-	-	0.0002
154	S25KK_009MH	-	-	-	-	-	-	0.0002
155	S27KK_142MH	-	-	-	-	-	-	0.0001
156	S33QQ_037MH	-	-	-	-	-	-	0.0001

3.3.6 Baseline Hydraulic Flow Restriction

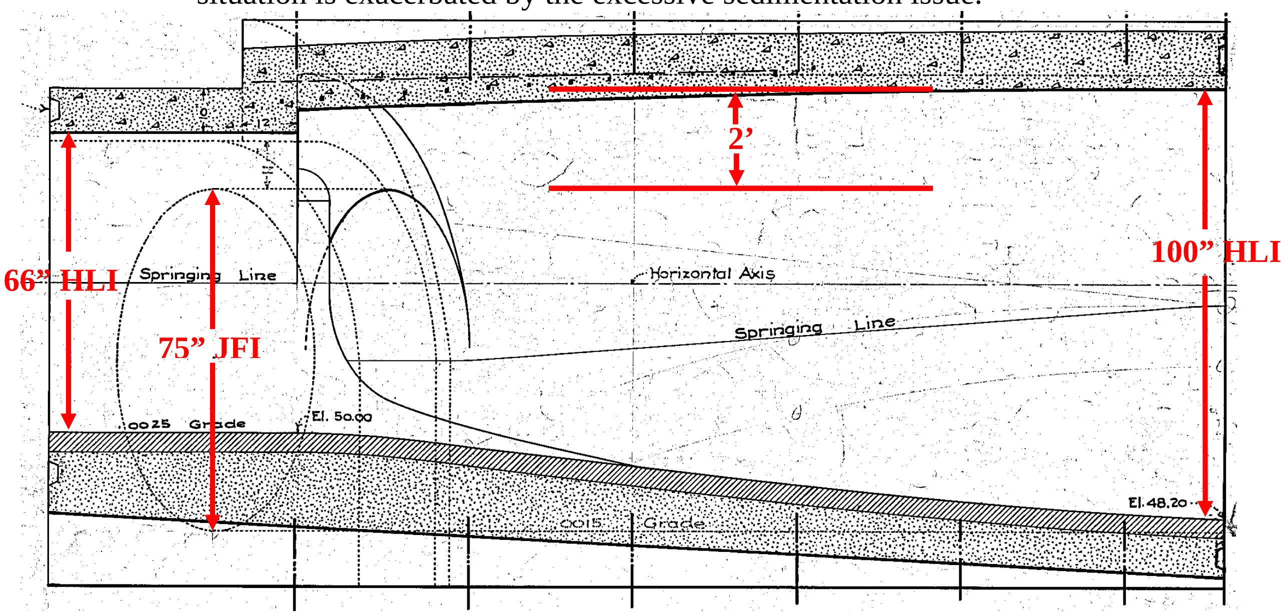
One of the requirements of the Consent Decree is to identify and map all components of the wastewater collection system that restrict flow of wastewater through the collection system that cause or contribute, or are likely to cause or contribute, to overflows from the collection system. InfoWorks CS has the ability to determine system components that restrict flow, thus potentially leading to an overflow. This analysis is performed by the software, where the slope of each sewer segment is compared to the slope of the hydraulic grade line at peak flow. A surcharged sewer with a pipe slope that is flatter than the slope of the hydraulic grade line indicates that the sewer is restricting flow, i.e., a bottleneck. If the pipe slope is steeper than the slope of the hydraulic grade line, then the surcharge is not necessarily caused by a capacity limitation in that pipe. This indicates that the sewer segment is in a backwater condition caused by a downstream control. Maps 3.3.6A, 3.3.6B, and 3.3.6C depict the results of this analysis, showing the smallest storm event restricted leading to an upstream overflow. A summary of pipe sizes and cumulative lengths identified are shown in Table 3.3.6.

TABLE 3.3.6 BASELINE RESTRICTION LENGTH (FT) PER PIPE SIZE AND STORM EVENT							
Diameter	**3 Month**	**1 Year**	**2 Year**	**5 Year**	**10 Year**	**15 Year**	**20 Year**
<10"	-	2,032	2,873	6,920	9,881	10,920	11,685
10" - 19"	-	2,640	10,212	19,737	35,659	48,686	56,162
20" - 29"	32	285	6,060	13,579	16,140	19,872	20,323
30" - 39"	-	-	-	640	3,033	4,265	4,536
>40"	2,476	2,476	10,202	14,118	16,219	16,620	16,842
Total Length	2,508	7,433	29,347	54,994	80,932	100,363	109,548

Most of the pipe capacity deficiencies are due to excessive inflow/infiltration into the system (hydraulic capacity). However, there are a few locations where construction defects and maintenance issues are the main culprit of SSOs. The sketch below depicts the locations of these flow restrictions. The following section describes these areas and their impact to the capacity of the collection system:

1. Sediment in the Lower Jones Falls.
   The Lower Jones Falls Interceptor is over half filled with sediment and debris based on the field inspections. This reduces the capacity of the system from approximately 78 MGD to 25 MGD, a reduction of almost 70 percent. The effects of this are felt far upstream and is the leading cause of overflows along the Lower Jones Falls Interceptor up to the Jones Falls Siphon. In addition, the side branches that drain into the Lower Jones Falls back up due to the elevated sewage levels in the Lower Jones Falls Interceptor, namely the Maryland Avenue Interceptor.

2. Lower Jones Falls Interceptor Entering the High Level at the Invert
   The 75-inch diameter Lower Jones Fall Interceptor (JFI) connects to the 66-inch High Level Interceptor (HLI) at the intersection of Eager Street and Brentwood Avenue and continues downstream as a 100-inch diameter interceptor. At this bell mouth structure, the 66-inch pipe and the 100-inch pipe connect near the crowns of each other. However, the JFI connects to the HLI at the invert. That means when the HLI is filled to the top of pipe, which it frequently is, the JFI is already surcharged by 2 feet, regardless of the flow from the Jones Falls. This situation is exacerbated by the excessive sedimentation issue.



3. 12-inch Diameter Pipe Reducing to a 8" Diameter Pipe in Maryland Avenue
   In the upper reaches of the Maryland Avenue Interceptor, there is a reach of 12-inch diameter pipe that reduces down to an 8-inch diameter pipe, then back up to a very flat 12-inch pipe. The 8-inch line and the flat 12-inch line restrict the flow and cause SSOs upstream.

3.3.7 Baseline Maximum Allowable Flows Before Overflows

One of the requirements of the Consent Decree is to identify system components that restrict flow and quantify the maximum flows that the identified components can handle before an overflow occurs (CD Paragraph 9.F.v.a and b). With the goal of removing SSOs from the system, the main concern is whether a component cause an overflow or not, and if so, when does it occur. The system components identified that lead to SSOs and their level of service provided (storm return period that causes an overflow) are discussed in Section 3.3.6.

4.0 FUTURE (YEAR 2025) ANALYSIS AND CAPACITY ASSESSMENT

4.1 General

The Consent Decree states that future conditions shall be based on projections for populations and sewer condition deterioration for year 2020. The City has since decided that the future projections will be based on Year 2025 to provide consistency with the Consent Decree for Baltimore County. Future population estimates are based on projections determined by the Baltimore Metropolitan Council. An ESRI shape file of the SSAs with the future population data was provided by the Technical Program Manager. The hydraulic impact of pipe deterioration has been represented by increasing groundwater infiltration by 10 percent. Detailed analysis for estimating future flows are discussed in the City's December 2007 Report *Current and Future Dry Weather Base Sanitary Flows*.

4.2 Dry Weather Capacity Assessment

A similar dry weather flow assessment was done on the future flows as completed for the baseline flow conditions. The only difference in the future flow to the baseline flow is an additional 2.1 MGD combined base sanitary flow and infiltration. There is no difference between the Future and Baseline models to the pipes that are surcharged or 75 percent full. Figure 3.2 depicts the peak percent full each pipe is during dry weather flow.

4.3 Wet Weather Capacity Assessment

4.3.1 Storm Events

Similar to baseline conditions, there are seven design storms that are to be analyzed for the future flows. These same design storms include: a three-month storm having a duration equal to the time of concentration for the sewershed (5 hours), 1, 2, 5, 10, 15, and 20-year, 24 hour duration storms. The storm distribution chosen for analysis is the NRCS/NOAA Atlas 14 distribution. The storm depths for the seven design storms are as follows:

- 3 Month – 1.11 inches
- 1 Year – 2.67 inches
- 2 Year – 3.23 inches
- 5 Year – 4.15 inches
- 10 Year – 4.97 inches
- 15 Year – 5.41 inches
- 20 Year – 5.82 inches

4.3.2 Return Period Analysis

One of the requirements of the CD is to run a Return Period Analysis (RPA) on the seven design storms. InfoWorks compares the surcharge state and any flooding based on each design storm and presents the minimum size storm required to surcharge and flood (cause an overflow) a pipe segment, along with the estimated flood volume. The results of the future flooding RPA are presented in Figure 4.3.2A, 4.3.2B, and 4.3.2C

4.3.3 Jones Falls Pumping Station Analysis

There are no planned improvements to the Jones Fall Pumping Station between the baseline conditions model and year 2025. Therefore the same parameters are utilized in the future conditions model.

The minimum dry weather flow to the pump station is 10.7 MGD and the average daily dry weather flow is 15.4 MGD. The peak pump station flow rates and velocities of the force mains for future conditions are presented below in Table 4.3.3.

TABLE 4.3.3
JONES FALLS PUMPING STATION FUTURE CAPACITY ANALYSIS**

Event	Peak Flow Incoming Flow Rate (MGD)	Peak Discharge Flow Rate (MGD)	Peak Bypassed Flow* Rate (MGD)	Peak Velocity (fps) in 48" FM	Peak Velocity (fps) in 54" FM
DWF	22.38	25.03	0.00	3.30	2.50
3 Month	31.66	31.73	0.00	3.91	3.10
1 Year	49.79	49.79	0.00	6.13	5.68
2 Year	56.04	52.10	4.05	6.41	6.19
5 Year	61.08	52.06	9.13	6.41	6.30
10 Year	63.80	53.00	10.92	6.53	6.48
15 Year	64.94	53.09	11.98	6.54	6.69
20 Year	66.13	53.17	13.08	6.55	6.85

* For flow above the capacity of the station, the flow is bypassed to the Lower Jones Falls Interceptor.
**The flow rates are peak instantaneous flow rates at three different locations which could occur at different times.

Similar to the Baseline Assessment, the velocities of the pump station remain below 7 feet per second, but there is little room for expansion of the station without upgrading the force main to be able to handle the higher return frequency storms.

4.3.4 Stony Run Pumping Station Analysis

There are no planned improvements to the Stony Run Pumping Station between the baseline conditions model and year 2025. Therefore the same parameters are utilized in the future conditions model. Since the Stony Run Pumping Station is only a wet weather pump station, it does not have a minimum and average daily flow. The peak pump station flow rates and force main velocities for future conditions are presented below in Table 4.3.4.

TABLE 4.3.4 STONY RUN PUMPING STATION FUTURE CAPACITY ANALYSIS**				
Event	Peak Flow Incoming Flow Rate (MGD)	Peak Discharge Flow Rate (MGD)	Peak Bypassed Flow Rate (MGD)	Peak Velocity (fps) in 30" FM
DWF	4.60	0.00	4.60	0.00
3 Month	7.97	0.00	7.97	0.00
1 Year	13.60	10.84	9.43	3.42
2 Year	16.12	11.68	9.59	3.68
5 Year	19.72	12.65	9.60	3.99
10 Year	23.15	13.75	9.61	4.33
15 Year	24.63	15.76	9.56	4.97
20 Year	26.10	17.73	9.61	5.59

**The flow rates are peak instantaneous flow rates at three different locations which could occur at different times.

The velocity of the sewage within the Stony Run force main for all seven design storms remain below 7 feet per second. However, the available capacity of the force main cannot be utilized without making improvements to the Jones Falls force main.

4.3.5 Predicted SSO Overflows

Figures 4.3.2A, 4.3.2B, and 4.3.2C present the storm return period required to cause an overflow at a manhole for the future conditions. Table 4.4.5A presents SSO volumes for all seven design storms at each engineered SSO and the cumulative overflows from all manholes in the Jones Falls sewershed. Table 4.3.5B shows each manhole ID and SSO volume for each corresponding storm.

TABLE 4.3.5A FUTURE SSO VOLUMES						
Event	All Manholes (MG)	SSO 33 (MG)	SSO 34 (MG)	SSO 67 (MG)	SSO 72 (MG)	Total (MG)
3 Month	0.211	0.000	0.000	0.689	0.000	0.900
1 Year	4.661	0.000	0.000	1.268	0.620	6.549
2 Year	6.214	0.447	0.250	2.046	0.627	9.584
5 year	14.088	1.336	0.768	3.683	3.615	23.490
10 Year	23.409	1.907	1.208	2.349	3.471	32.344
15 Year	28.169	2.157	1.420	2.121	3.629	37.497
20 Year	32.430	2.359	1.586	2.166	3.679	42.220

TABLE 4.3.5B FUTURE MANHOLE SSO VOLUMES								
	Manhole ID	3 month (MG)	1 Year (MG)	2 Year (MG)	5 Year (MG)	10 Year (MG)	15 Year (MG)	20 Year (MG)
1	S31KK_099MH	0.1225	0.9709	1.8343	3.1376	6.1415	7.2421	7.9106
2	S35GG_086MH	0.0881	3.5228	3.6331	6.3636	6.7624	6.6802	6.7268
3	S31CC_016MH	-	0.0616	0.0952	0.1285	0.1543	0.1679	0.1811
4	S31CC_039MH	-	0.0540	0.0754	0.1109	0.1399	0.1559	0.1716
5	S33II1024MH	-	0.0150	0.0364	0.0742	0.1054	0.1219	0.1370
6	S33GG_010MH	-	0.0125	0.0453	0.0776	0.1032	0.1162	0.1282
7	S33GG_087MH	-	0.0116	0.1009	0.2571	0.3850	0.4565	0.5204
8	S31GG1008MH	-	0.0077	0.0149	0.0300	0.0435	0.0505	0.0562
9	S31II1003MH	-	0.0039	0.0079	0.0170	0.0259	0.0311	0.0360
10	S31CC_003MH	-	0.0009	0.0374	0.1207	0.1957	0.2372	0.2747
11	S04II2018MH	-	0.0005	0.0274	0.1226	0.2401	0.3119	0.3843
12	S15EE2032MH	-	-	0.1456	0.4166	0.5642	0.6326	0.6914
13	S33GG_002MH	-	-	0.0309	0.1073	0.1777	0.2170	0.2533
14	S35GG_010MH	-	-	0.0294	0.1157	0.1993	0.2468	0.2911
15	S33QQ1015MH	-	-	0.0207	0.1341	0.2206	0.2724	0.3177
16	S02AA2008MH	-	-	0.0192	0.0137	0.1120	0.1256	0.1366
17	S02WW1007MH	-	-	0.0126	0.0998	0.1439	0.1577	0.1681
18	S11EE2014MH	-	-	0.0117	0.7283	1.3143	1.5536	1.7518
19	S13EE2013MH	-	-	0.0090	0.0895	0.1312	0.1518	0.1704
20	S35KK1019MH	-	-	0.0077	0.0238	0.0335	0.0383	0.0426
21	S33GG_033MH	-	-	0.0069	0.0121	0.0157	0.0177	0.0193
22	S13EE2026MH	-	-	0.0062	0.1090	0.2407	0.2946	0.3451
23	S35II1021MH	-	-	0.0031	0.0148	0.0235	0.0271	0.0300
24	S29OO1109MH	-	-	0.0025	0.0488	0.1117	0.1625	0.2202
25	S31OO1005MH	-	-	0.0004	0.0108	0.0207	0.0261	0.0309
26	S33GG_019MH	-	-	0.0002	0.0073	0.0154	0.0201	0.0247
27	S02YY1005MH	-	-	0.0001	0.0115	0.0277	0.0334	0.0376
28	S09CC2101MH	-	-	-	0.3726	0.7477	0.9093	1.0407
29	S19GG2071MH	-	-	-	0.3320	0.8161	1.0414	1.2398
30	S23QQ1006MH	-	-	-	0.1821	0.3988	0.4911	0.5860
31	S07YY1016MH	-	-	-	0.1414	0.2228	0.2536	0.2798
32	S04AA2005MH	-	-	-	0.1030	0.2400	0.3178	0.3904
33	S04CC2003MH	-	-	-	0.0473	0.0718	0.0845	0.0966
34	S23EE1021MH	-	-	-	0.0467	0.0766	0.0938	0.1117
35	S23QQ1013MH	-	-	-	0.0437	0.1165	0.1880	0.2476
36	S07YY1001MH	-	-	-	0.0409	0.1716	0.2159	0.2490
37	S19EE2014MH	-	-	-	0.0403	0.2947	0.4505	0.5786
38	S33WW_041MH	-	-	-	0.0384	0.1423	0.2005	0.2432
39	S02WW1004MH	-	-	-	0.0318	0.1779	0.2739	0.3678
40	S17AA2009MH	-	-	-	0.0247	0.0398	0.046	0.0513

TABLE 4.3.5B FUTURE MANHOLE SSO VOLUMES								
	Manhole ID	3 month (MG)	1 Year (MG)	2 Year (MG)	5 Year (MG)	10 Year (MG)	15 Year (MG)	20 Year (MG)
41	S07YY1003MH	-	-	-	0.0191	0.0539	0.0677	0.0773
42	S07AA2026MH	-	-	-	0.0173	0.0450	0.0552	0.0631
43	S17CC2001MH	-	-	-	0.0141	0.0214	0.0245	0.0273
44	S35KK1001MH	-	-	-	0.0139	0.0387	0.0546	0.0702
45	S07YY1004MH	-	-	-	0.0131	0.0745	0.1012	0.1182
46	S09CC2039MH	-	-	-	0.0123	0.1109	0.1461	0.1739
47	S17AA2008MH	-	-	-	0.0104	0.0694	0.1072	0.1438
48	S04CC2001MH	-	-	-	0.0091	0.0618	0.0927	0.1215
49	S09AA2002MH	-	-	-	0.0086	0.0440	0.0663	0.0880
50	S23CC1042MH	-	-	-	0.0083	0.0268	0.0377	0.0475
51	S33II1031MH	-	-	-	0.0054	0.0130	0.0172	0.0211
52	S33QQ1005MH	-	-	-	0.0054	0.0128	0.0166	0.0201
53	S35QQ1021MH	-	-	-	0.0052	0.0194	0.0277	0.0353
54	S23EE1009MH	-	-	-	0.0051	0.0144	0.0181	0.0213
55	S07AA2028MH	-	-	-	0.0048	0.0289	0.0357	0.0409
56	S33QQ1014MH	-	-	-	0.0047	0.0165	0.0218	0.0268
57	S43UU_020MH	-	-	-	0.0043	0.0090	0.0108	0.0123
58	S31EE_015MH	-	-	-	0.0040	0.0279	0.0438	0.0602
59	S23KK_007MH	-	-	-	0.0036	0.0183	0.0286	0.0390
60	S11EE2021MH	-	-	-	0.0034	0.0299	0.0630	0.0824
61	S09CC2103MH	-	-	-	0.0031	0.1216	0.2137	0.2994
62	S15UU1001MH	-	-	-	0.0028	0.0591	0.1099	0.1296
63	S17CC2002MH	-	-	-	0.0022	0.0032	0.0037	0.0041
64	S23EE1010MH	-	-	-	0.0016	0.0033	0.0038	0.0044
65	S02YY1011MH	-	-	-	0.0015	0.0240	0.0450	0.0667
66	S31QQ_021MH	-	-	-	0.0014	0.0095	0.0154	0.0214
67	S19AA2060MH	-	-	-	0.0011	0.0083	0.0117	0.0148
68	S05UU1012MH	-	-	-	0.0005	0.0532	0.0932	0.1334
69	S33SS1002MH	-	-	-	0.0005	0.0222	0.0371	0.0520
70	S33SS1005MH	-	-	-	0.0003	0.0094	0.0141	0.0184
71	S43WW_007MH	-	-	-	0.0001	0.0099	0.0175	0.0253
72	S31MM_005MH	-	-	-	-	0.3768	0.4759	0.5626
73	S31MM_052MH	-	-	-	-	0.1998	0.2936	0.3571
74	S01AA2016MH	-	-	-	-	0.0899	0.1450	0.1992
75	S31MM_054MH	-	-	-	-	0.0745	0.3240	0.4350
76	S13CC2008MH	-	-	-	-	0.0479	0.0697	0.0824
77	S05YY1007MH	-	-	-	-	0.0458	0.1187	0.1931
78	S33YY1002MH	-	-	-	-	0.0322	0.0676	0.1055
79	S07YY1013MH	-	-	-	-	0.0316	0.0684	0.0916
80	S05II2011MH	-	-	-	-	0.0264	0.0654	0.0899

TABLE 4.3.5B FUTURE MANHOLE SSO VOLUMES								
	Manhole ID	3 month (MG)	1 Year (MG)	2 Year (MG)	5 Year (MG)	10 Year (MG)	15 Year (MG)	20 Year (MG)
81	S25EE1031MH	-	-	-	-	0.0252	0.0423	0.0584
82	S33KK_010MH	-	-	-	-	0.0248	0.0389	0.0496
83	S17KK1004MH	-	-	-	-	0.0229	0.0316	0.0386
84	S19II2024MH	-	-	-	-	0.0208	0.1304	0.2798
85	S09CC2007MH	-	-	-	-	0.0191	0.0470	0.0685
86	S15MM1003MH	-	-	-	-	0.0182	0.0318	0.0444
87	S13CC2006MH	-	-	-	-	0.0180	0.0209	0.0235
88	S43SS_027MH	-	-	-	-	0.0150	0.0259	0.033
89	S07AA2022MH	-	-	-	-	0.0145	0.0257	0.0361
90	S02EE2011MH	-	-	-	-	0.0136	0.0311	0.0504
91	S04II2007MH	-	-	-	-	0.0122	0.0299	0.0502
92	S07YY1018MH	-	-	-	-	0.0093	0.0177	0.0222
93	S09WW1002MH	-	-	-	-	0.0079	0.0196	0.0308
94	S13AA2012MH	-	-	-	-	0.0058	0.0333	0.0620
95	S15KK1029MH	-	-	-	-	0.0054	0.0071	0.0085
96	S33KK1006MH	-	-	-	-	0.0050	0.0099	0.0150
97	S35OO_008MH	-	-	-	-	0.0043	0.0178	0.0274
98	S13OO1017MH	-	-	-	-	0.0041	0.0178	0.0325
99	S27II_015MH	-	-	-	-	0.0024	0.0070	0.0117
100	S43SS_015MH	-	-	-	-	0.0023	0.0112	0.0227
101	S05AA2038MH	-	-	-	-	0.0013	0.0081	0.0125
102	S07YY1008MH	-	-	-	-	0.0013	0.0055	0.0101
103	S05AA2005MH	-	-	-	-	0.0007	0.0056	0.0088
104	S27AA1035MH	-	-	-	-	0.0004	0.0078	0.0171
105	S19CC2048MH	-	-	-	-	0.0003	0.0052	0.0085
106	S33QQ_013MH	-	-	-	-	0.0003	0.0028	0.0047
107	S37YY_007MH	-	-	-	-	0.0002	0.0115	0.0291
108	S43SS_033MH	-	-	-	-	0.0002	0.0056	0.0121
109	S33GG_025MH	-	-	-	-	0.0002	0.0001	0.0002
110	S15MM1008MH	-	-	-	-	0.0001	0.0017	0.0037
111	S17UU1008MH	-	-	-	-	-	0.0284	0.1109
112	S03WW1010MH	-	-	-	-	-	0.0279	0.0714
113	S05II2010MH	-	-	-	-	-	0.0180	0.0570
114	S03II2003MH	-	-	-	-	-	0.0139	0.0363
115	S07EE2016MH	-	-	-	-	-	0.0114	0.0404
116	S11CC2022MH	-	-	-	-	-	0.0103	0.0293
117	S13CC2021MH	-	-	-	-	-	0.0084	0.0212
118	S13UU1015MH	-	-	-	-	-	0.0072	0.0320
119	S13UU1010MH	-	-	-	-	-	0.0068	0.0266
120	S07YY1014MH	-	-	-	-	-	0.0061	0.0171

TABLE 4.3.5B
FUTURE MANHOLE SSO VOLUMES

	Manhole ID	3 month (MG)	1 Year (MG)	2 Year (MG)	5 Year (MG)	10 Year (MG)	15 Year (MG)	20 Year (MG)
121	S21II2012MH	-	-	-	-	-	0.0049	0.0170
122	S21AA2006MH	-	-	-	-	-	0.0037	0.0106
123	S35EE1025MH	-	-	-	-	-	0.0036	0.0143
124	S05AA2025MH	-	-	-	-	-	0.0034	0.0141
125	S39AA1011MH	-	-	-	-	-	0.0033	0.0091
126	S35OO_034MH	-	-	-	-	-	0.0032	0.0120
127	S19GG2020MH	-	-	-	-	-	0.0025	0.0064
128	S05YY1014MH	-	-	-	-	-	0.0019	0.0182
129	S11EE2018MH	-	-	-	-	-	0.0019	0.0074
130	S35MM_004MH	-	-	-	-	-	0.0015	0.0046
131	S45UU_021MH	-	-	-	-	-	0.0012	0.0071
132	S21EE2018MH	-	-	-	-	-	0.0011	0.0064
133	S35YY_009MH	-	-	-	-	-	0.0006	0.0071
134	S39YY_020MH	-	-	-	-	-	0.0005	0.0030
135	S33QQ_012MH	-	-	-	-	-	0.0005	0.0020
136	S05II2019MH	-	-	-	-	-	0.0004	0.0101
137	S23AA1015MH	-	-	-	-	-	0.0004	0.0019
138	S31GG1013MH	-	-	-	-	-	0.0002	0.0010
139	S15KK1013MH	-	-	-	-	-	0.0001	0.0004
140	S06II2006MH	-	-	-	-	-	-	0.0109
141	S08CC2010MH	-	-	-	-	-	-	0.0106
142	S33UU1016MH	-	-	-	-	-	-	0.0086
143	S23YY_060MH	-	-	-	-	-	-	0.0045
144	S03WW1016MH	-	-	-	-	-	-	0.0037
145	S08II2005MH	-	-	-	-	-	-	0.0017
146	S31MM_013MH	-	-	-	-	-	-	0.0017
147	S09UU1001MH	-	-	-	-	-	-	0.0014
148	S35OO_055MH	-	-	-	-	-	-	0.0010
149	S33SS_038MH	-	-	-	-	-	-	0.0007
150	S35YY_036MH	-	-	-	-	-	-	0.0007
151	S13OO1020MH	-	-	-	-	-	-	0.0003
152	S31OO1019MH	-	-	-	-	-	-	0.0003
153	S04CC2008MH	-	-	-	-	-	-	0.0002
154	S25KK_009MH	-	-	-	-	-	-	0.0002
155	S27KK_142MH	-	-	-	-	-	-	0.0002
156	S33QQ_037MH	-	-	-	-	-	-	0.0001

4.3.6 Hydraulic Flow Restriction

One of the requirements of the Consent Decree is to identify and map all components of the wastewater collection system that restrict flow of wastewater through the collection system that cause or contribute, or are likely to cause or contribute, to overflows from the collection system. InfoWorks CS has the capability to determine which system components that restrict flow, thus potentially leading to an overflow. Maps 4.3.6A, 4.3.6B, and 4.3.6C depict the results of this analysis. A summary of pipe sizes and cumulative lengths identified are shown in Table 4.3.6.

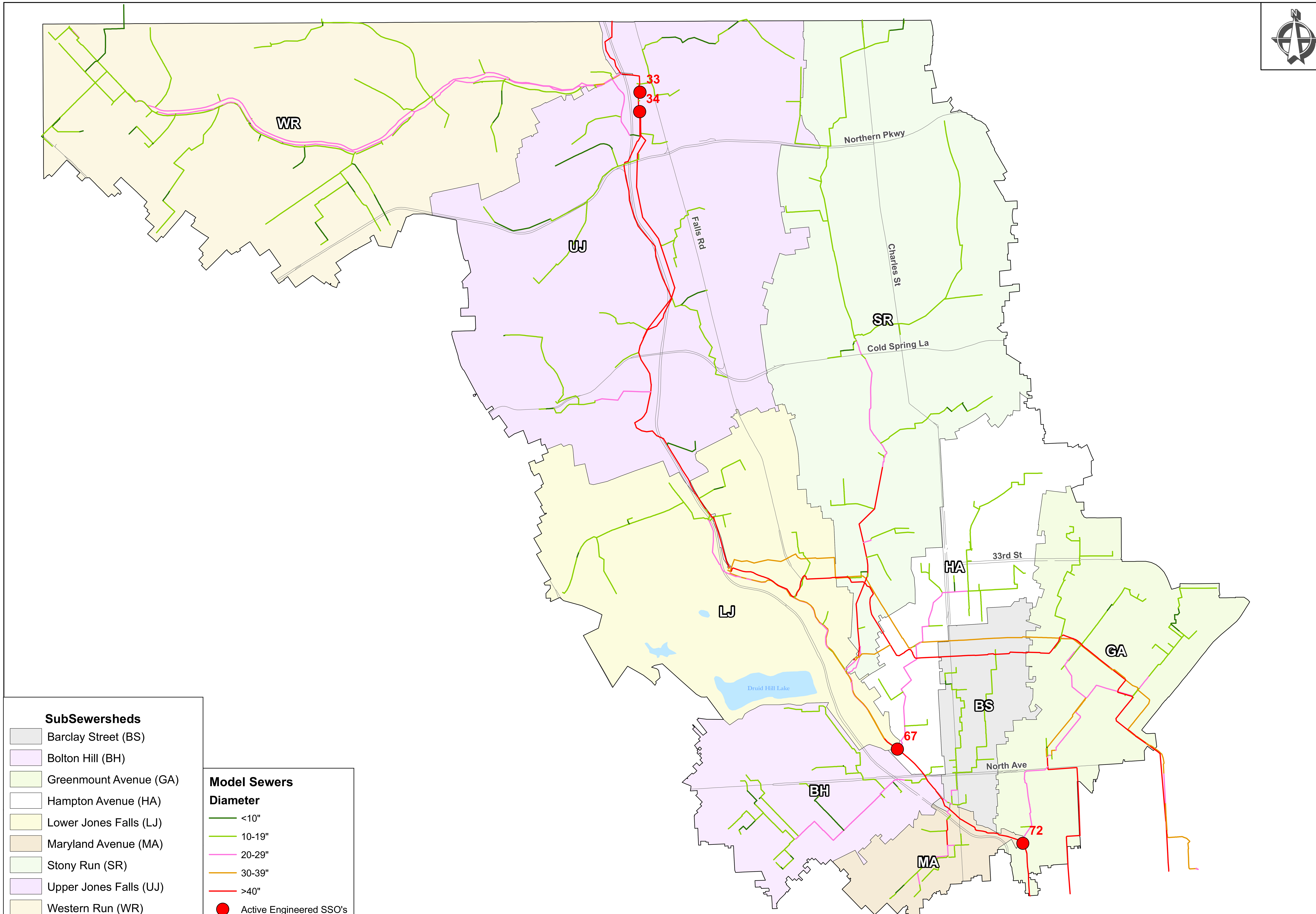
TABLE 4.3.6
FUTURE RESTRICTION LENGTH (FT) PER PIPE SIZE AND STORM EVENT

Diameter	3 Month	1 Year	2 Year	5 Year	10 Year	15 Year	20 Year
<10"	-	2,032	2,553	7,065	9,875	11,354	12,318
10" - 19"	-	2,640	9,367	20,882	40,045	51,042	58,022
20" - 29"	32	285	6,464	14,197	18,594	20,743	21,324
30" - 39"	-	-	-	1,468	4,142	4,576	5,229
>40"	2,476	2,476	10,202	14,126	16,918	17,426	17,506
Total Length	2,508	7,433	28,586	57,738	89,574	105,141	114,399

The same construction defects and maintenance issues that contribute to capacity deficiencies that are in the baseline model are in the future conditions model. For a description, see Section 3.3.6.

4.3.7 Future Maximum Allowable Flows Before Overflows

One of the requirements of the Consent Decree is to identify system components that restrict flow and quantify the maximum flows that the identified components can handle before an overflow occurs (CD Paragraph 9.F.v.a and b). With the goal of removing SSOs from the system, the main concern is does a component cause an overflow or not, and if so, when does it occur. The system components identified that lead to SSOs and their level of service provided (storm return period that causes an overflow) are discussed in Section 4.3.6. The Future Model will be used to develop alternatives to eliminate all SSOs caused by the identified restrictions.



In association with

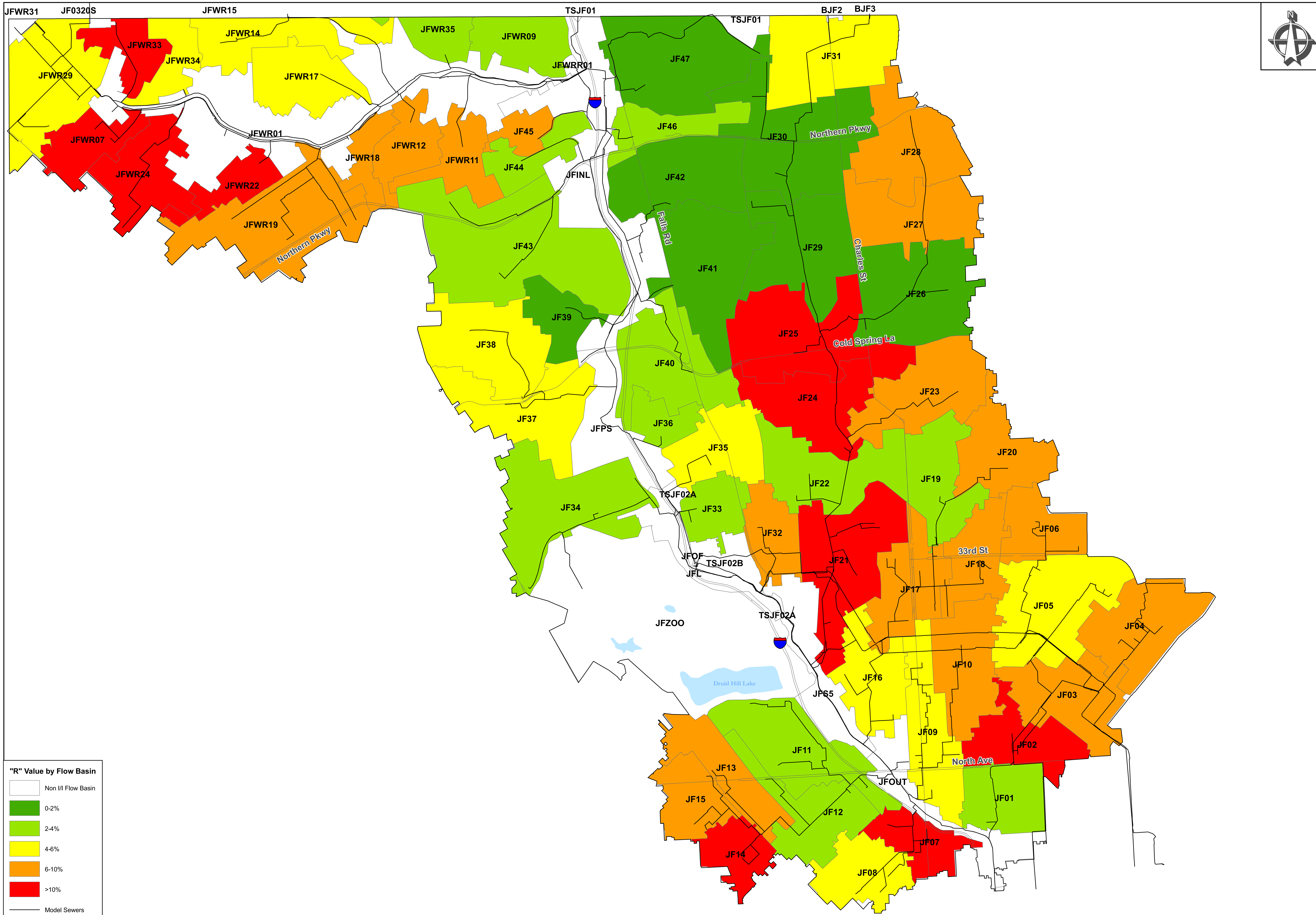
October 2008

Scale: 1 inch = 0.5 miles

Jones Falls Sewershed Project Area

Project 994 - Jones Falls Collection System Evaluation & Sewershed Plan

FIG 1.1



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October 2008

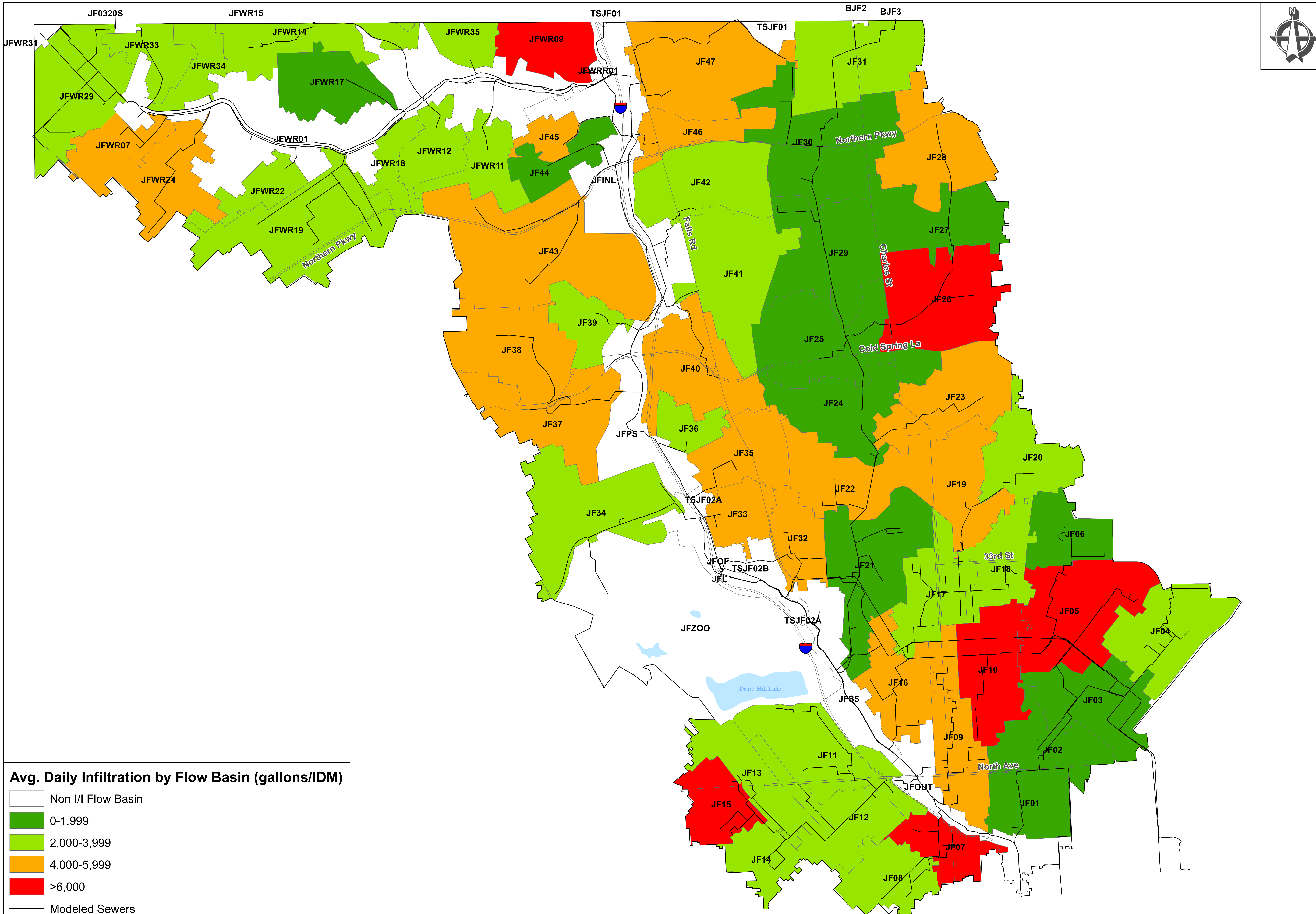
Scale: 1 inch = 0.5 miles

Jones Falls R Values Capture Coefficient

Project 994 - Jones Falls Collection System Evaluation & Sewershed Plan

CITY OF BALTIMORE

FIG 2.2.3A



In association with

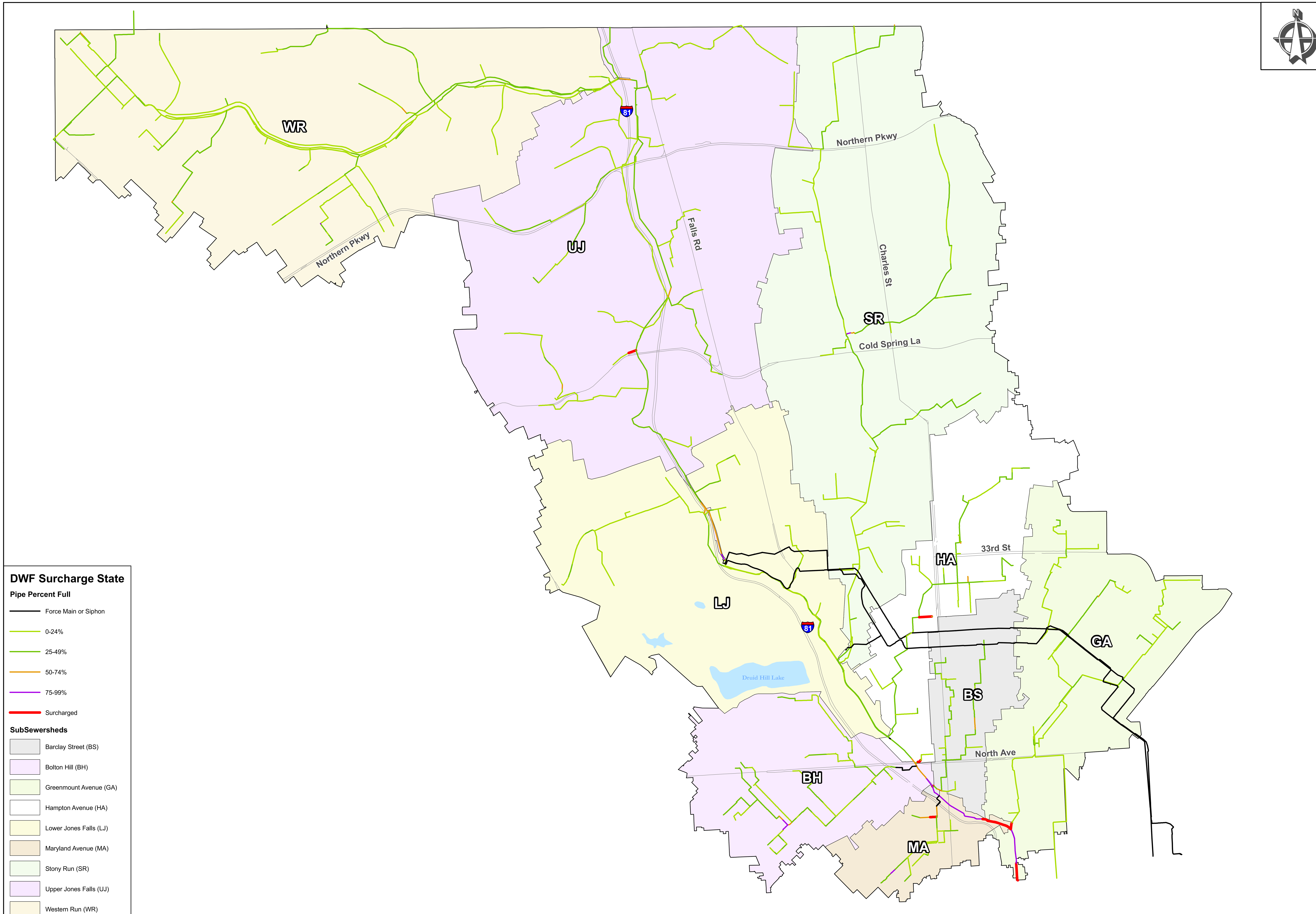
October 2008

Scale: 1 inch = 0.5 miles

Jones Falls Baseline Model Average Daily Infiltration

Project 994 - Jones Falls Collection System Evaluation & Sewershed Plan

FIG 2.2.3B



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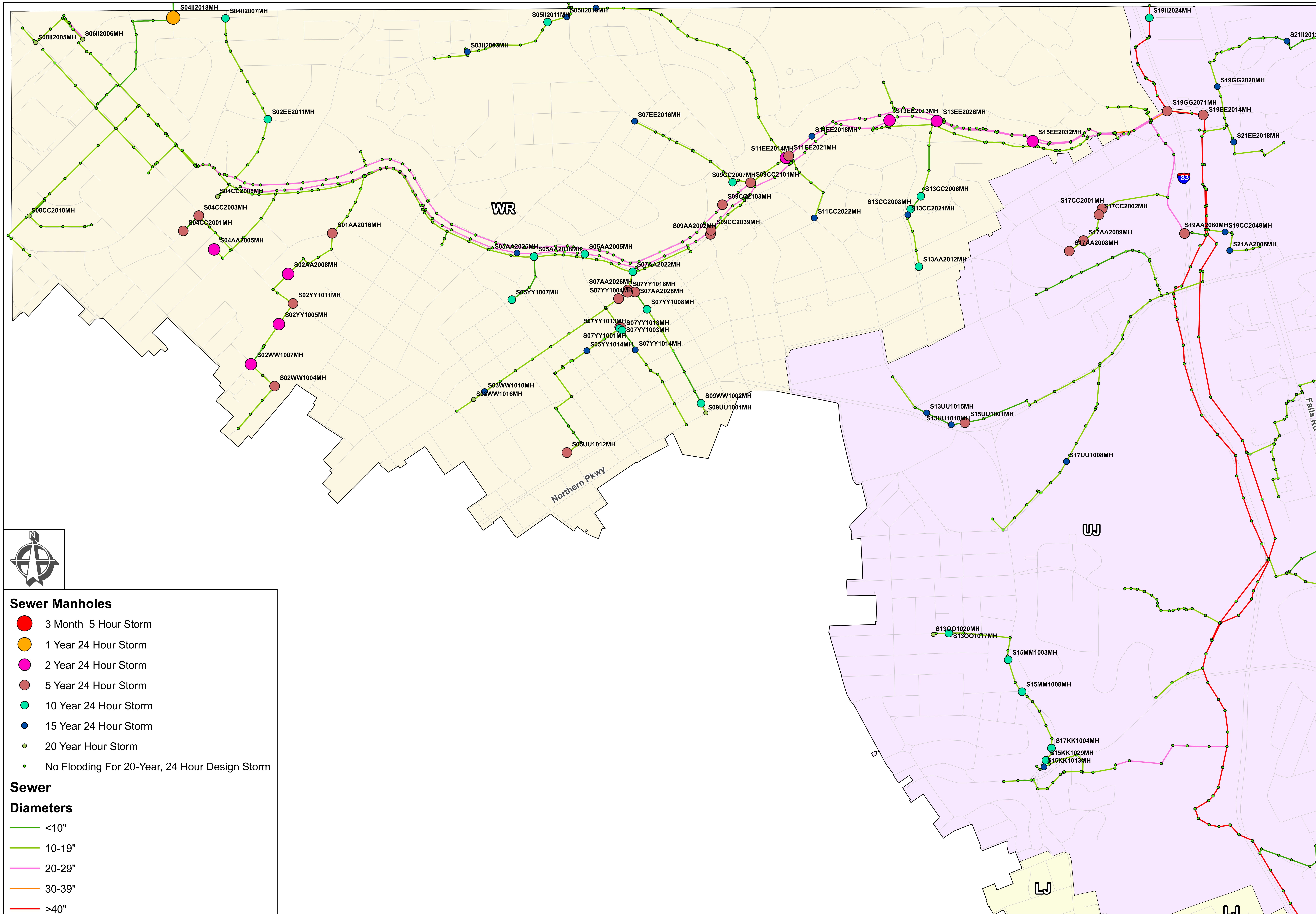
Scale: 1 inch = 0.5 miles

Jones Falls Baseline & Future Conditions Dry Weather Capacity Assessment

Project 994 - Jones Falls Collection System Evaluation & Sewershed Plan

CITY OF BALTIMORE

FIG 3.2



In association with

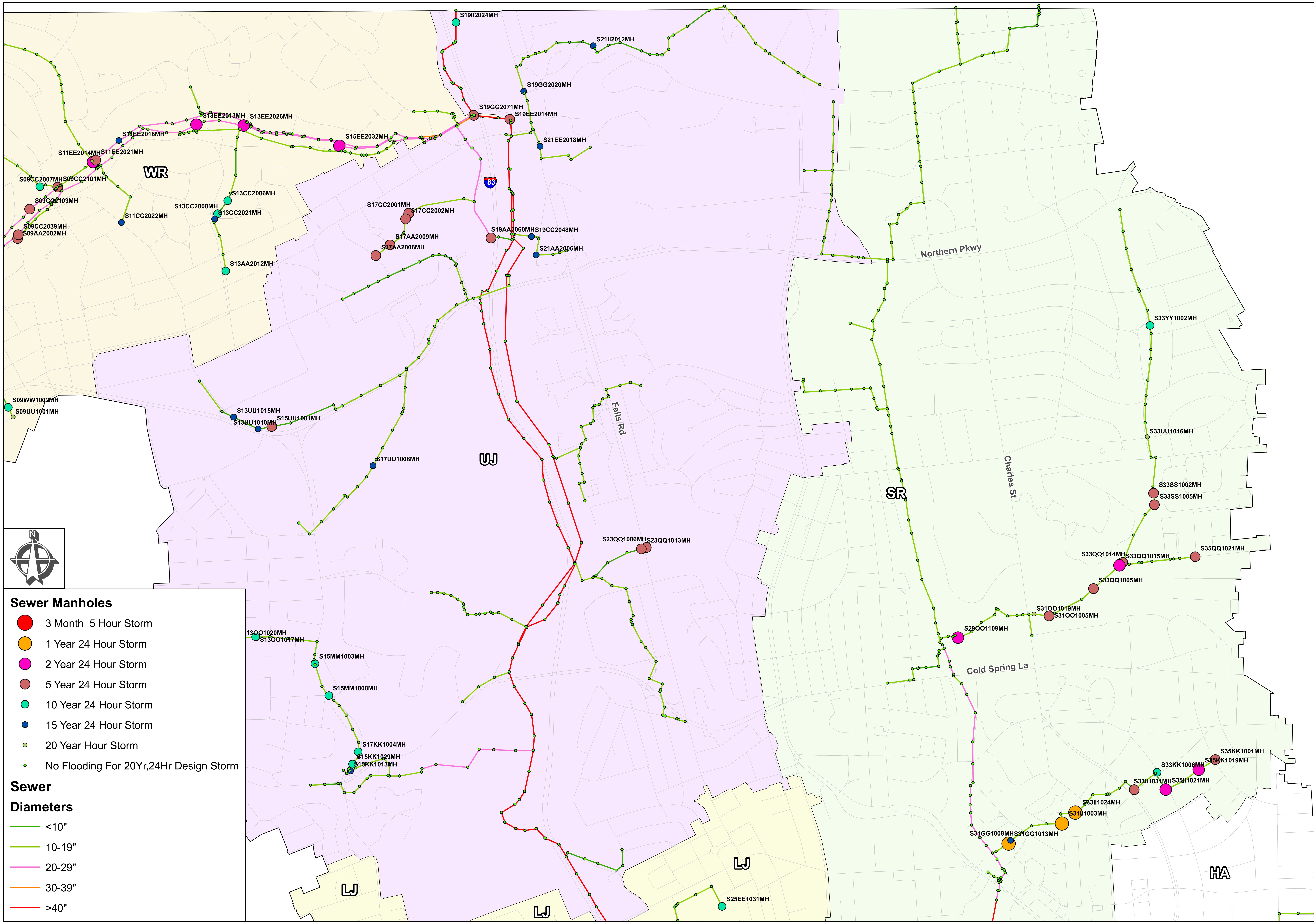
October 2008

Scale: 1 inch = 0.25 miles

Jones Falls Baseline Conditions Flooding Return Period Analysis

Project 994 - Jones Falls Collection System Evaluation & Sewershed Plan

FIG 3.3.2A



In association with

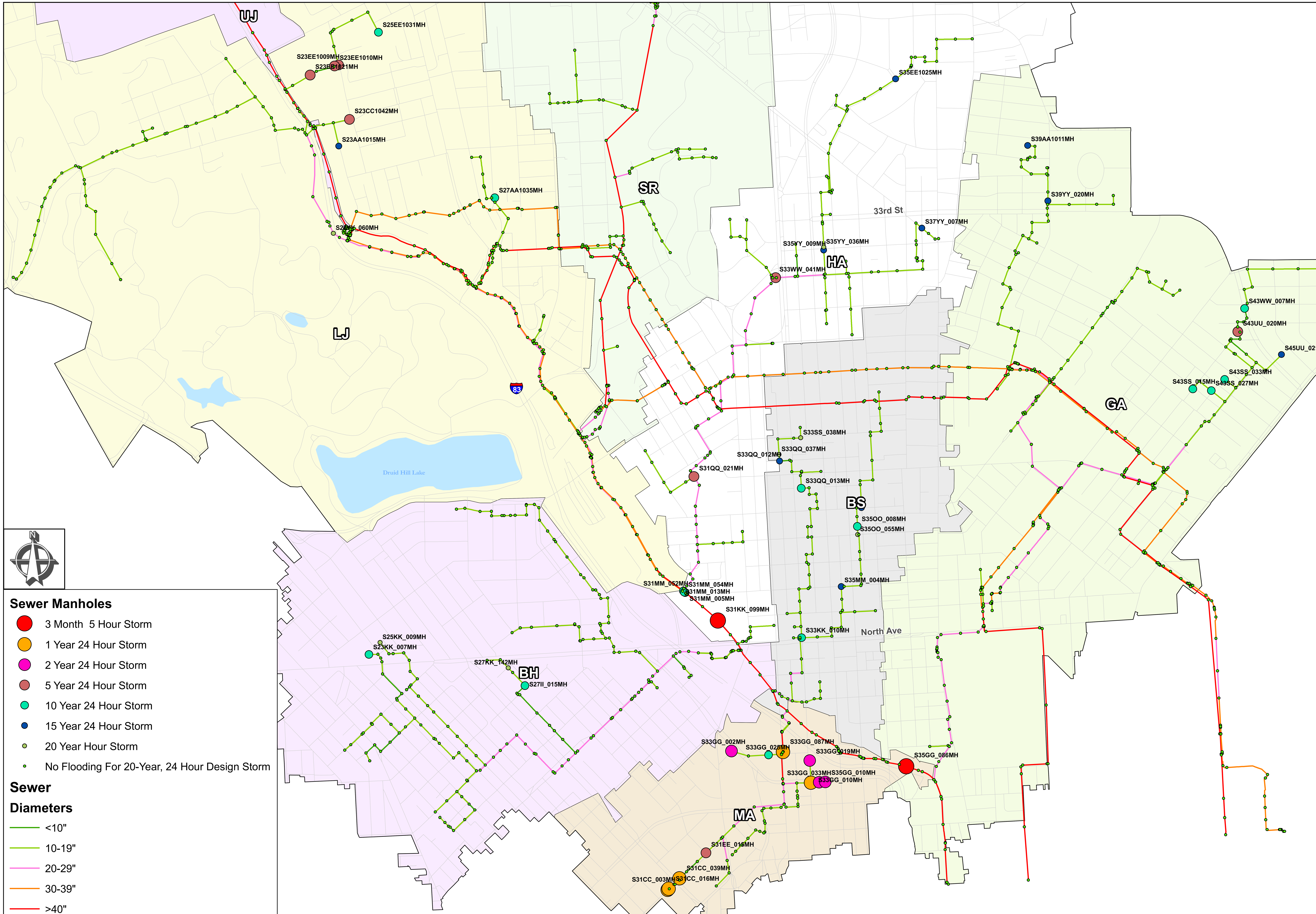
October 2008

Scale: 1 inch = 0.25 miles

Jones Falls Baseline Conditions Flooding Return Period Analysis

Project 994 - Jones Falls Collection System Evaluation & Sewershed Plan

FIG 3.3.2B



In association with

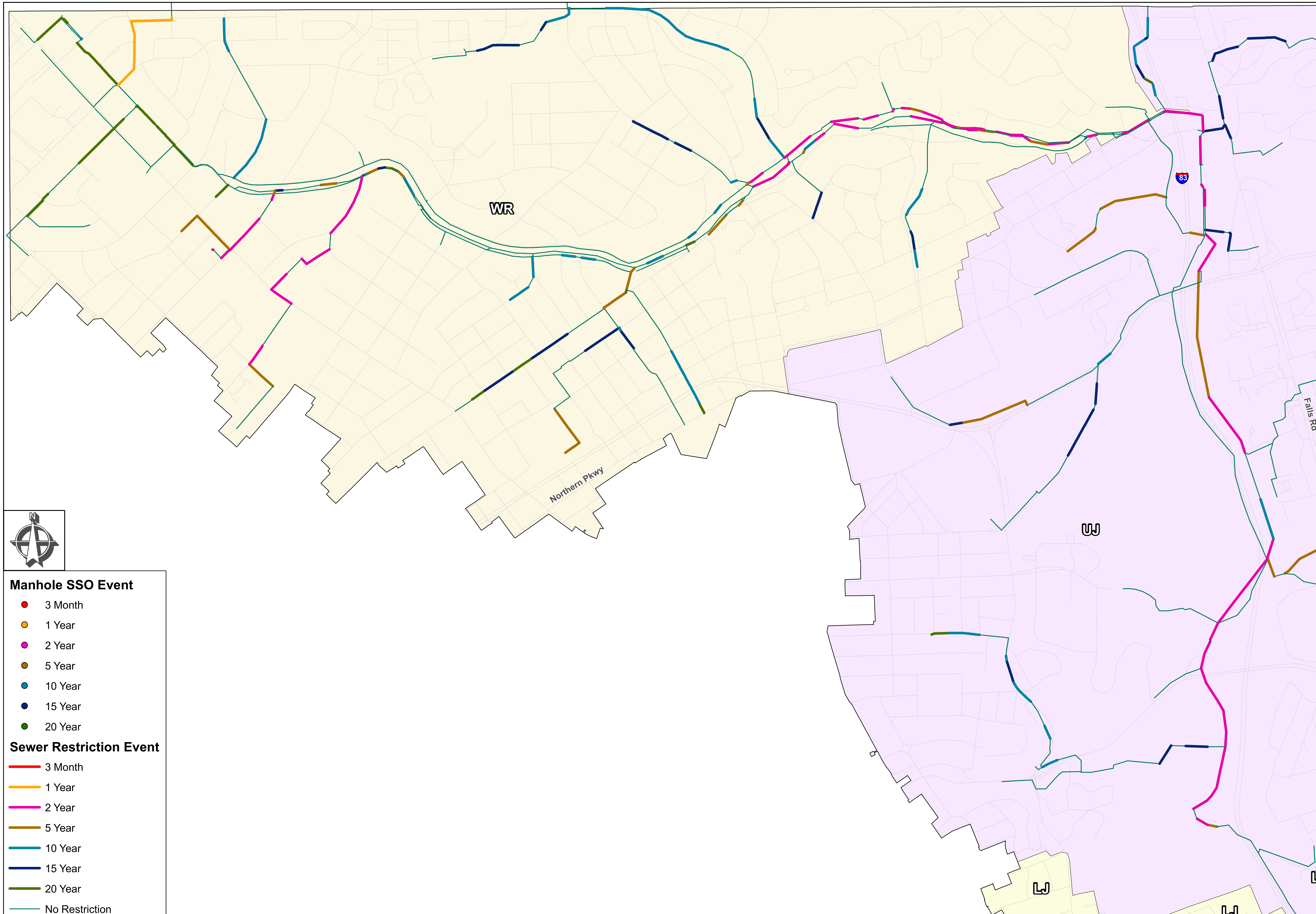
October 2008

Scale: 1 inch = 0.25 miles

Jones Falls Baseline Conditions Flooding Return Period Analysis

Project 994 - Jones Falls Collection System Evaluation & Sewershed Plan

FIG 3.3.2C



In association with

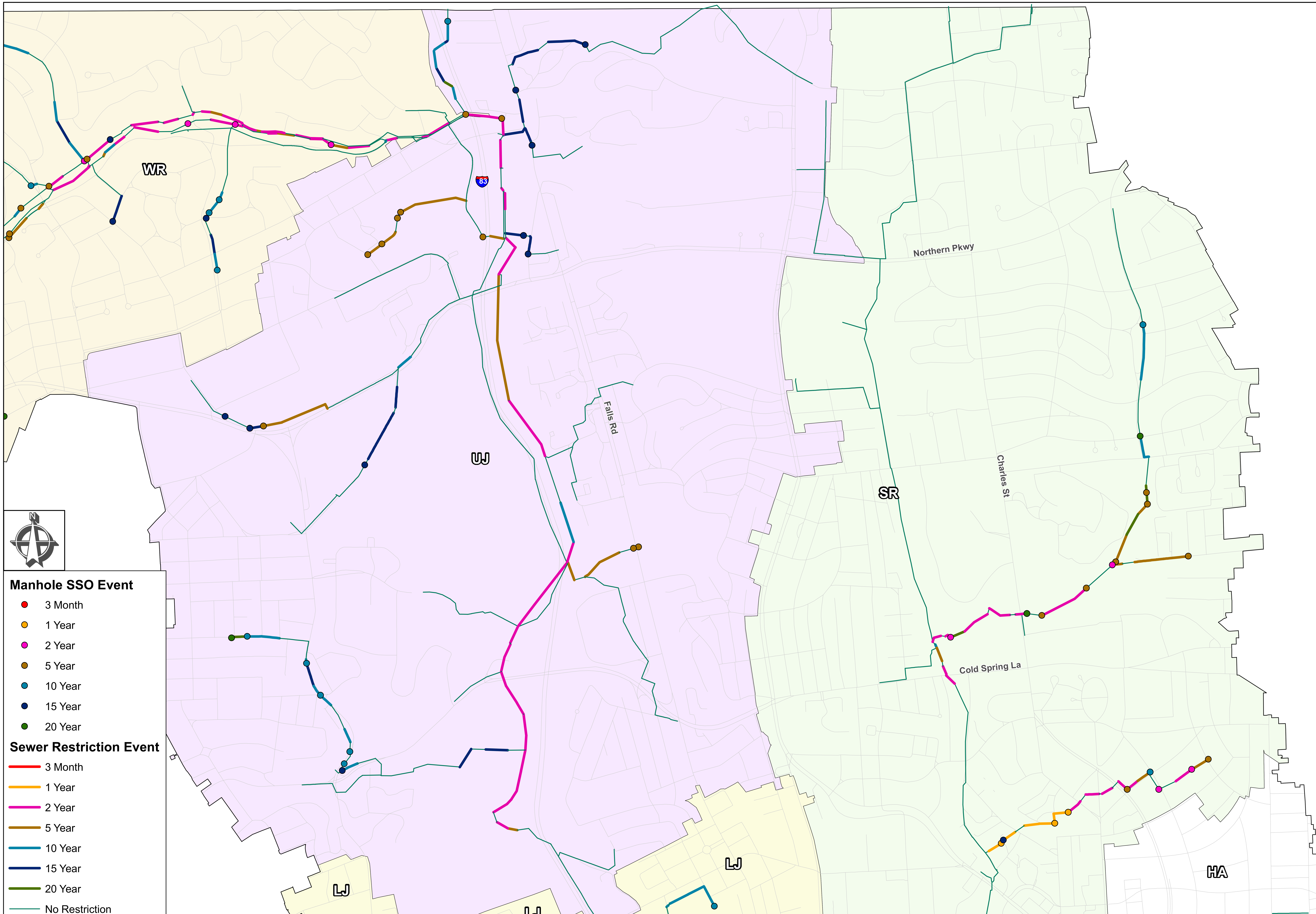
October 2008

Scale: 1 inch = 0.25 miles

Jones Falls
Baseline Conditions
Hydraulic Restriction Analysis

Project 994 - Jones Falls
Collection System Evaluation
& Sewershed Plan

FIG 3.3.6A



In association with

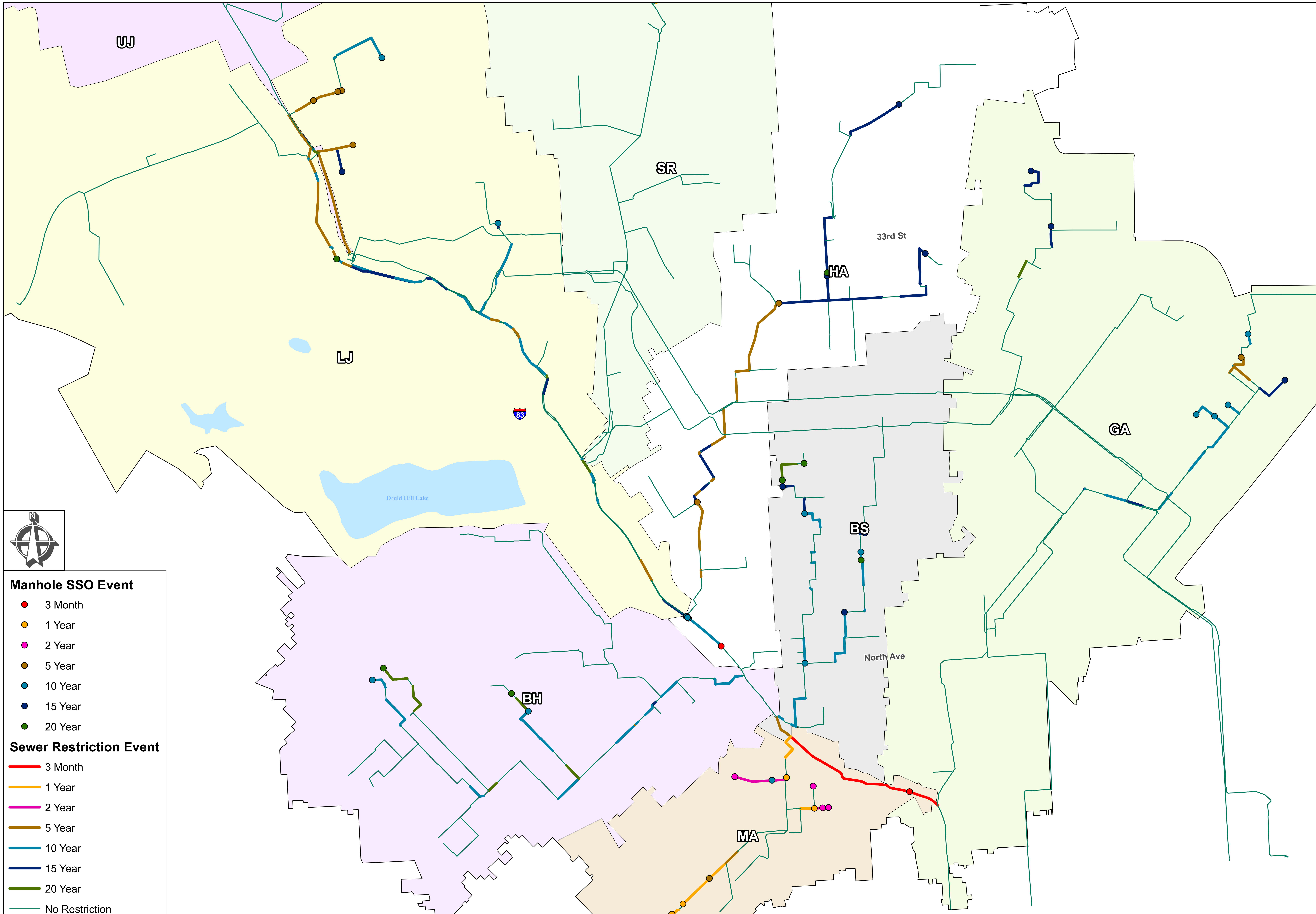
October 2008

Scale: 1 inch = 0.25 miles

Jones Falls Baseline Conditions Hydraulic Restriction Analysis

Project 994 - Jones Falls Collection System Evaluation & Sewershed Plan

FIG 3.3.6B



In association with

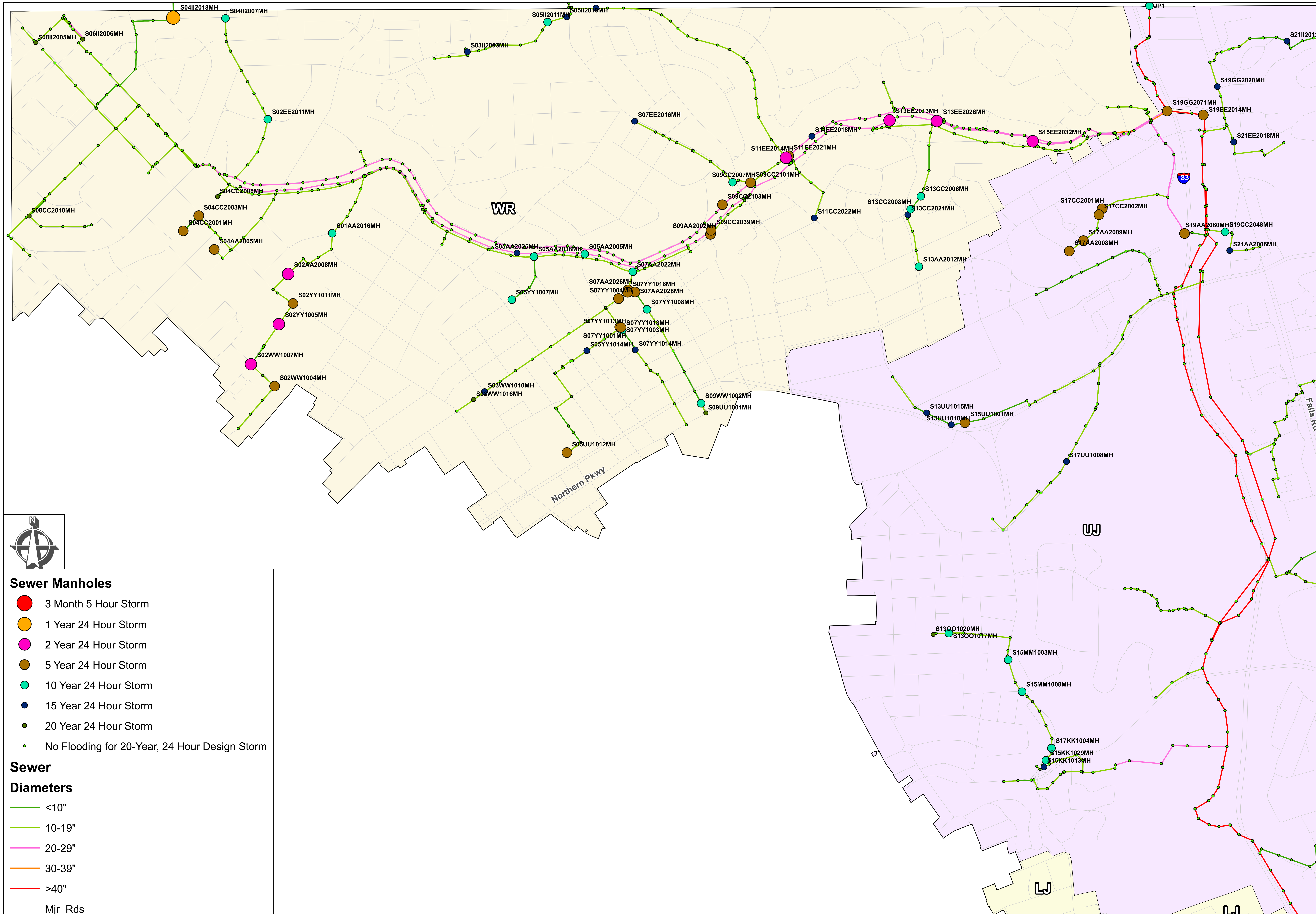
October 2008

Scale: 1 inch = 0.25 miles

Jones Falls Baseline Conditions Hydraulic Restriction Analysis

Project 994 - Jones Falls Collection System Evaluation & Sewershed Plan

FIG 3.3.6C



Jones Falls Future Conditions-2025 Flooding Return Period Analysis

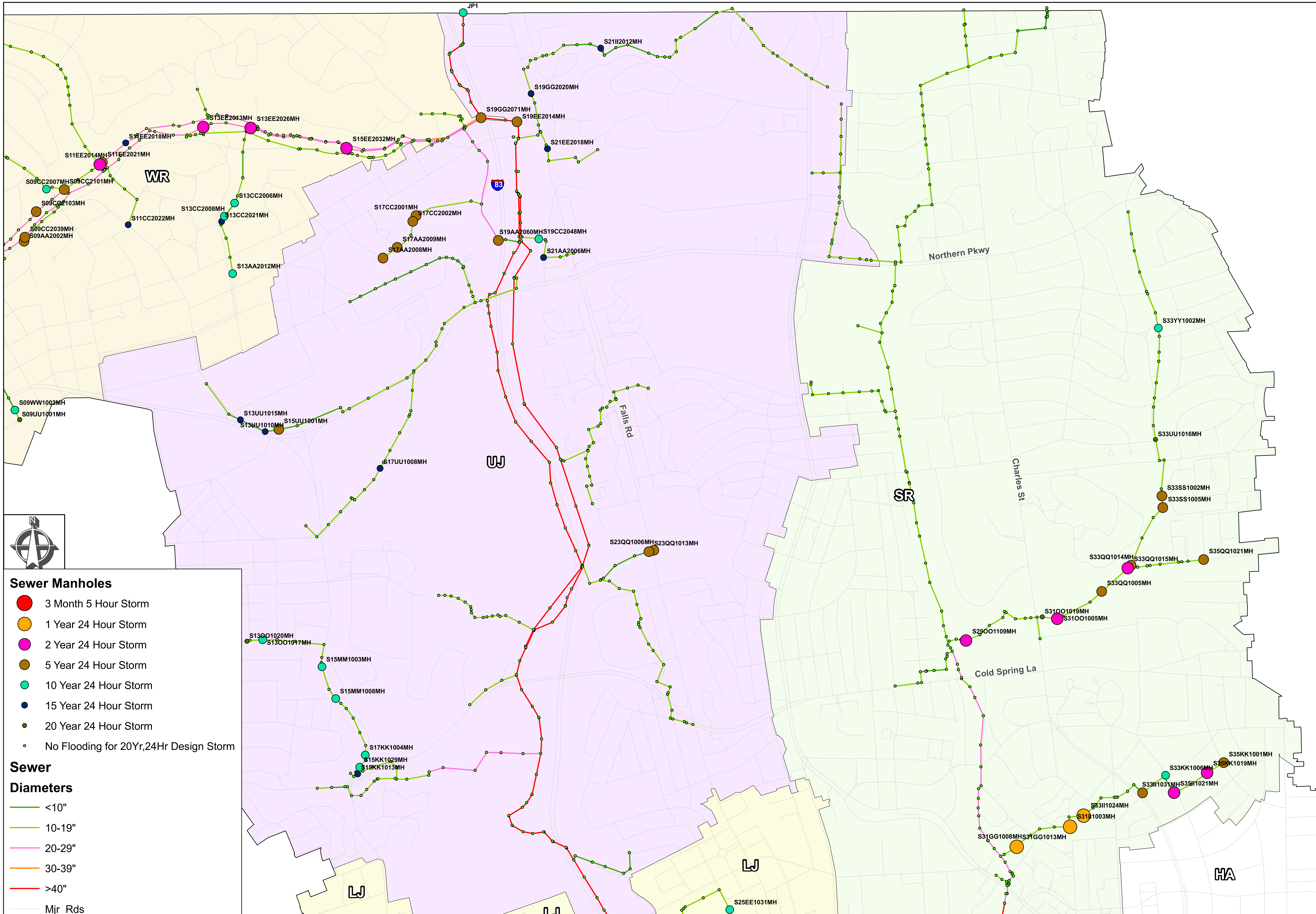
Project 994 - Jones Falls Collection System Evaluation & Sewershed Plan

In association with

October 2008

Scale: 1 inch = 0.25 miles

FIG 4.3.2A



In association with

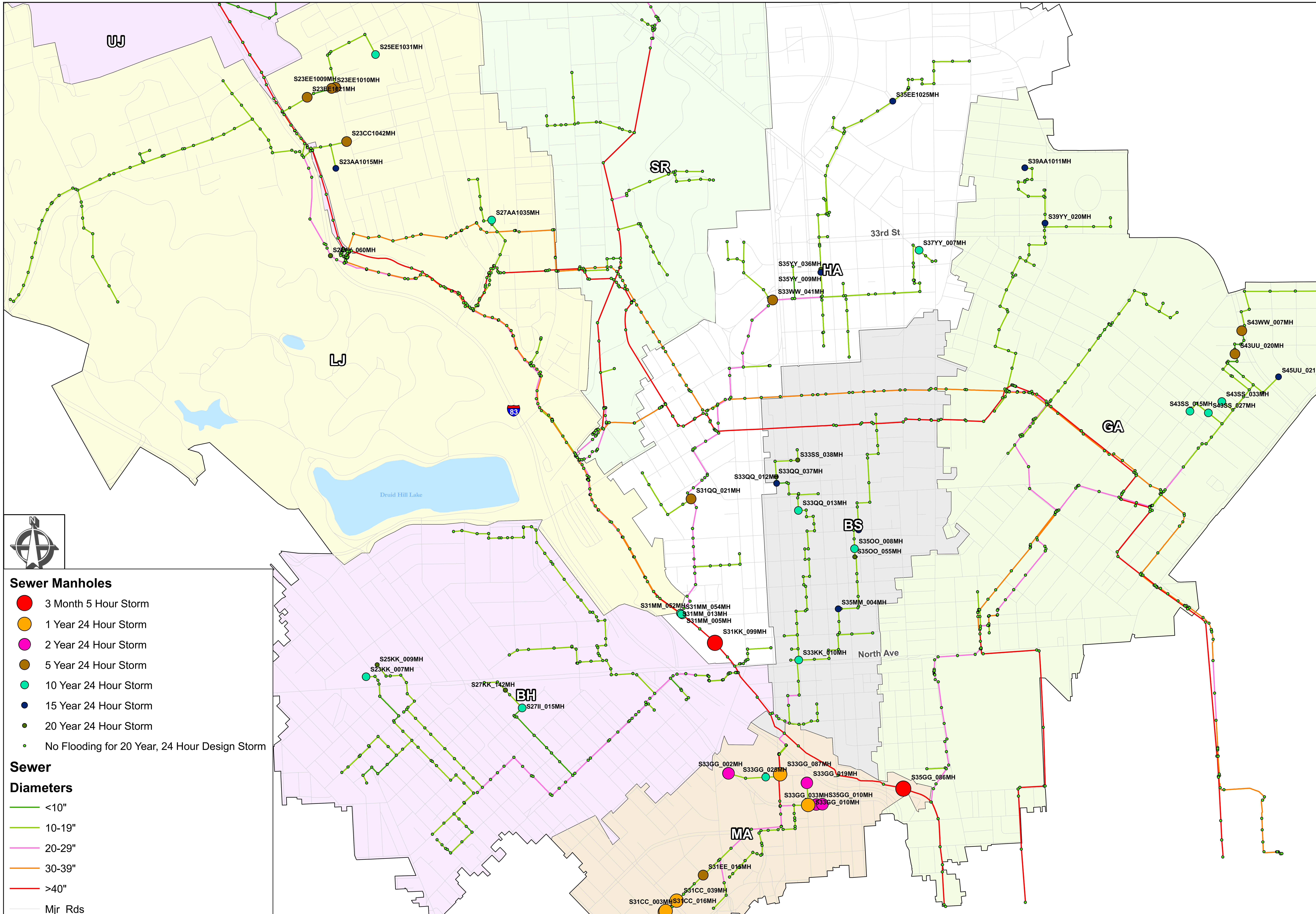
October 2008

Scale: 1 inch = 0.25 miles

Jones Falls
Future Conditions-2025
Flooding Return
Period Analysis

Project 994 - Jones Falls
Collection System Evaluation
& Sewershed Plan

FIG 4.3.2B



In association with

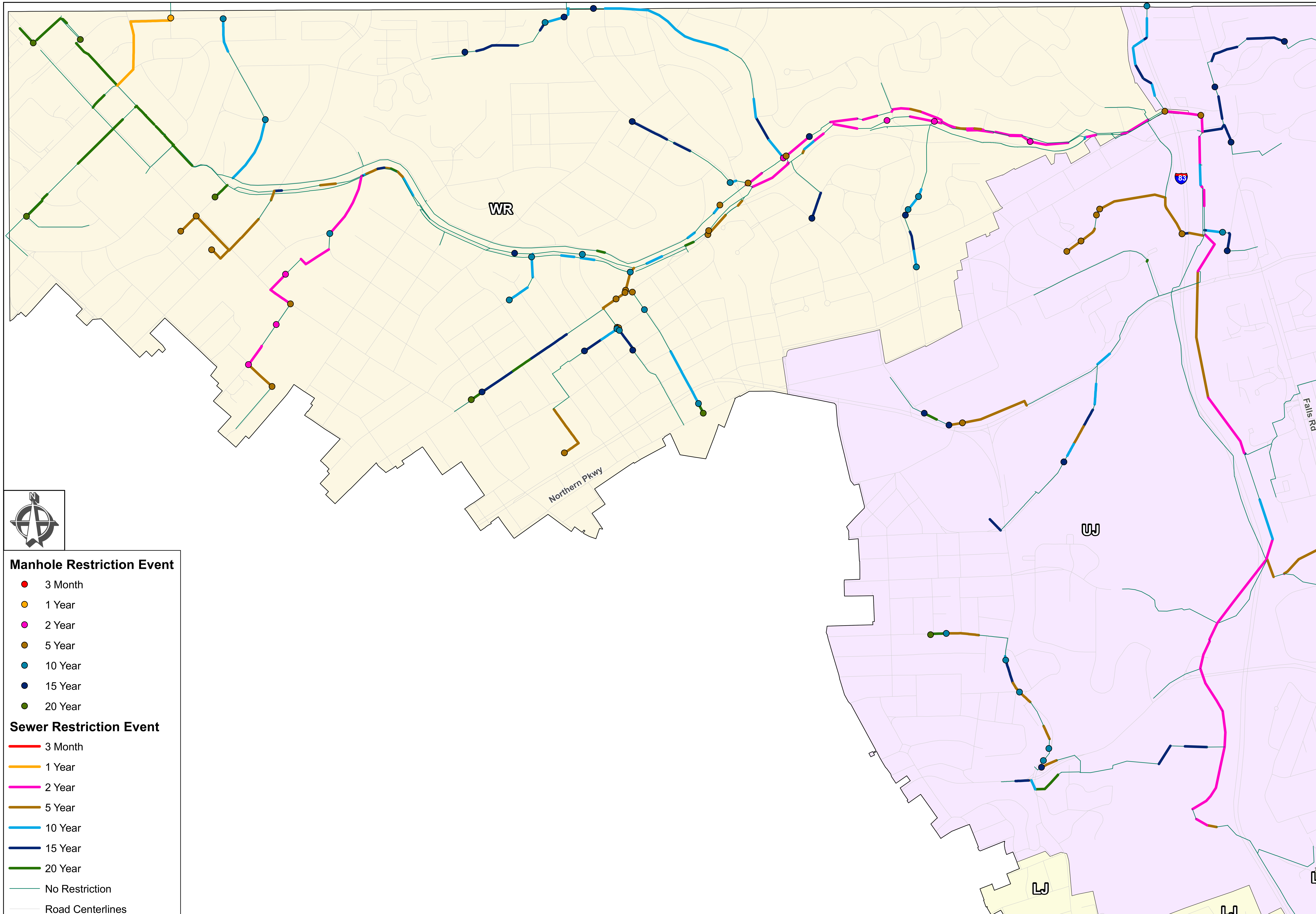
October 2008

Scale: 1 inch = 0.25 miles

Jones Falls Future Conditions-2025 Flooding Return Period Analysis

Project 994 - Jones Falls Collection System Evaluation & Sewershed Plan

FIG 4.3.2C



In association with

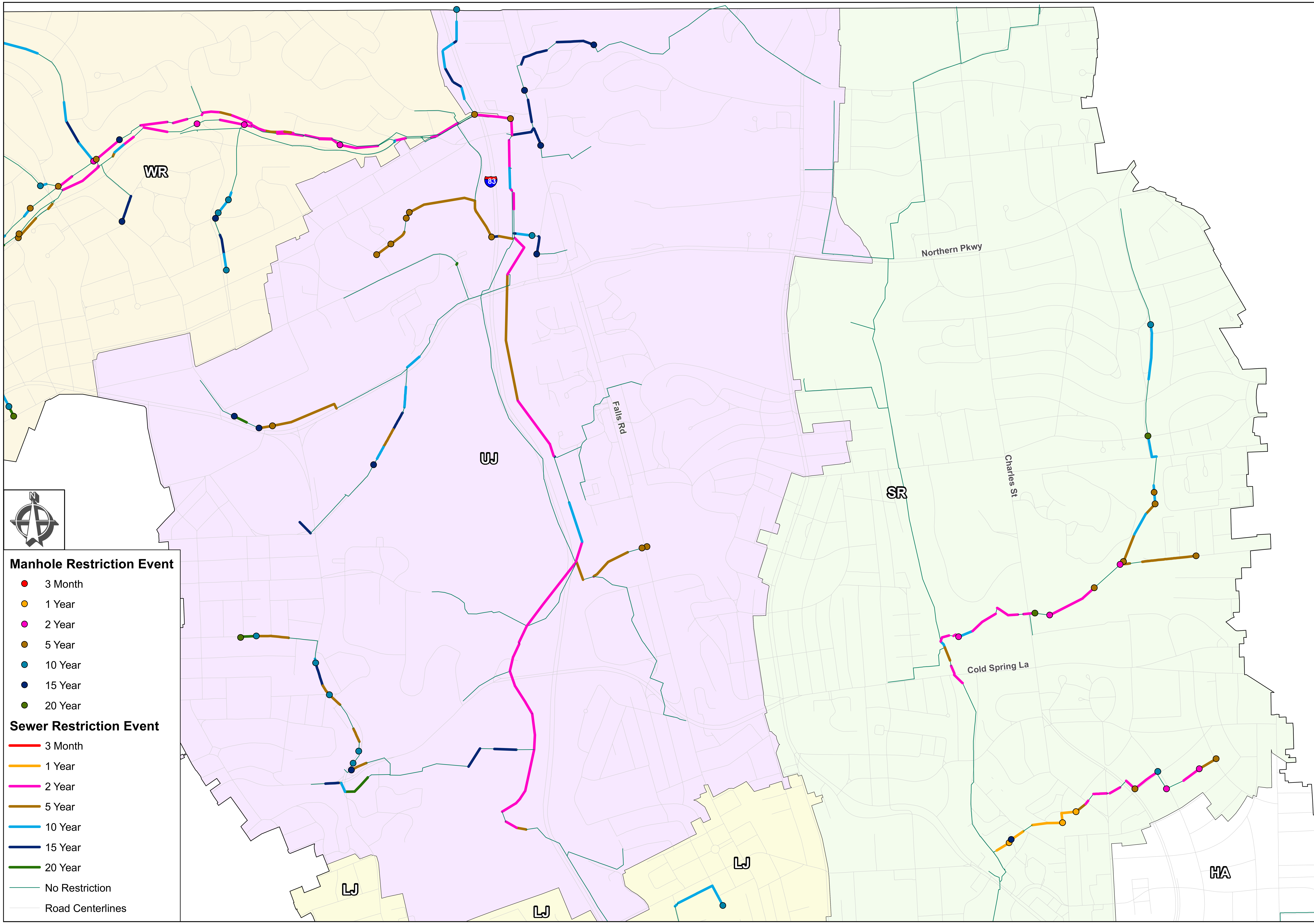
October 2008

Scale: 1 inch = 0.25 miles

Jones Falls Future Conditions-2025 Hydraulic Restriction Analysis

Project 994 - Jones Falls Collection System Evaluation & Sewershed Plan

FIG 4.3.6A



In association with

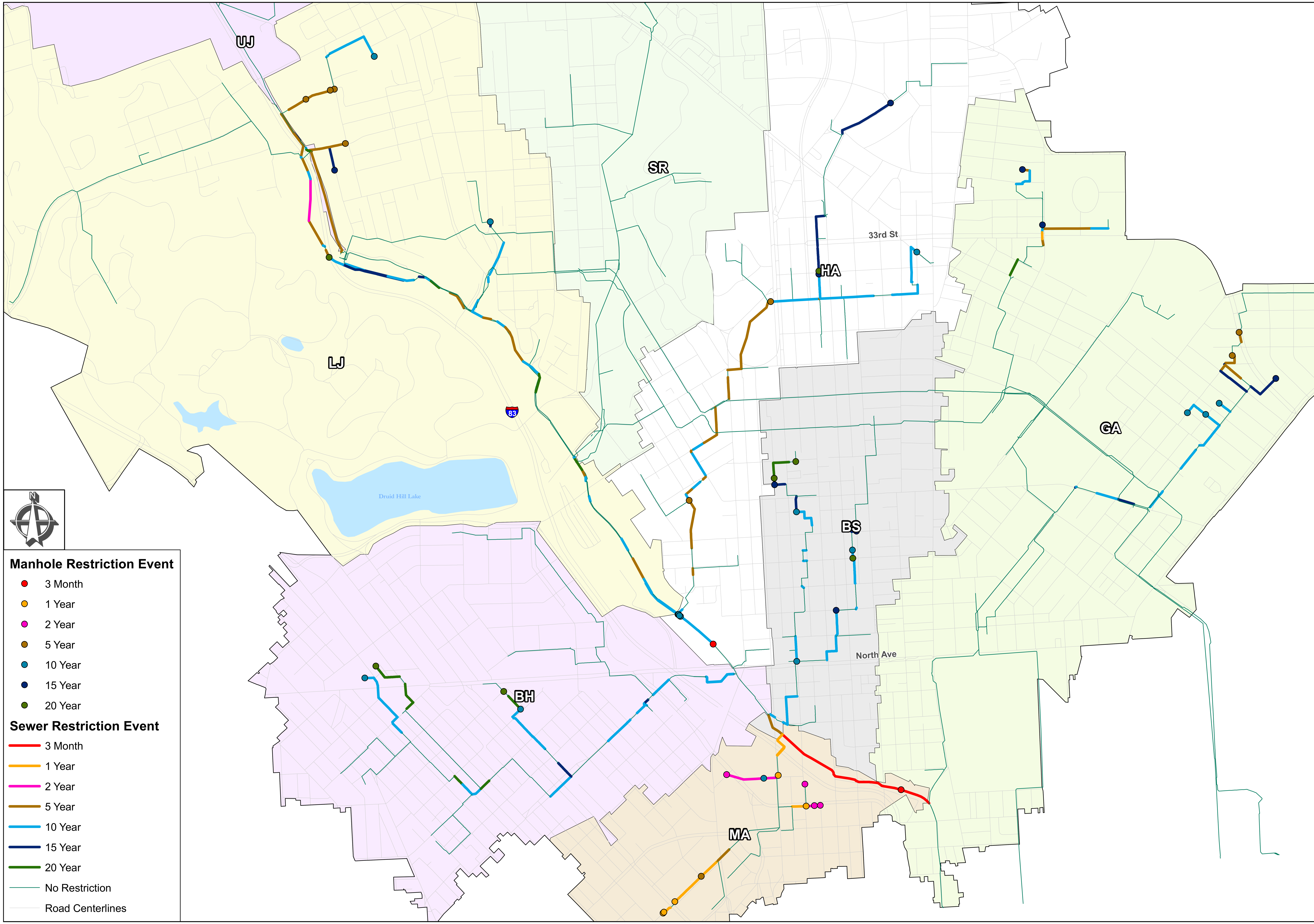
October 2008

Scale: 1 inch = 0.25 miles

Jones Falls Future Condtions-2025 Hydraulic Restriction Analysis

Project 994 - Jones Falls Collection System Evaluation & Sewershed Plan

FIG 4.3.6B



In association with

October 2008

Scale: 1 inch = 0.25 miles

Jones Falls Future Conditions-2025 Hydraulic Restriction Analysis

Project 994 - Jones Falls Collection System Evaluation & Sewershed Plan

FIG 4.3.6C